9-1-2003

Effects of operator training method on knowledge retention on a common CNC machine interface

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Master's Thesis

Effects of Operator Training Method on Knowledge Retention on a Common CNC Machine Interface

September 2003

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The following graduate thesis, completed by Phillip A. Rogerson, is submitted in partial fulfillment of the requirements for the degree of Master of Science in Industrial and Systems Engineering.

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Acknowledgments

My sincerest gratitude goes out to all those who contributed to the success of my graduate studies and this project.

I would especially like to thank my advisor, Dr. Jacqueline Mozrall, who guided me through the thesis process and gave me direction, advice and pep-talks while I was researching and writing this paper.

Thanks also go to Mr. Madhu Nair, who served on my thesis committee, and was the source for many valuable suggestions.

I thank Dr. Jake Shealy for encouraging me to pursue graduate studies at RIT, Marilyn Houck for sending me to the right people at the right time, Martin Haas who has done so much to make the Brinkman machine tools lab what it is, and Josh Quick and John Bonzo for their assistance during the pilot study.

Of course, I have to thank my late parents for their love and patience, and for encouraging my curiosity and the love of learning that were so vital to my success. I wish you could have been here to see it completed.

Finally, my deepest love and unending thanks go to my wife Lisa for her support, patience, humor, understanding and unfaltering love during my time at RIT. Now we can have a normal life!

Phillip Rogerson
September, 2003
Rochester Institute of Technology

Abstract:

The continued growth of computer numerically controlled (CNC) machine tool use in industry combined with increased competition in the global market requires workers to quickly attain requisite skills and raise productivity levels to meet production demands. Retention of knowledge is a key factor in an operator's ability to transfer training into actual machine operation in a production setting. This study examines the difference in short term retention of knowledge necessary to perform basic interface operations in operators trained using a conventional training method compared to those trained using a train-to-criteria method.

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1. Problem Statement and Definition

In a previous study of two common CNC controllers, it was found that CNC machine tool user interfaces violate many principles of usability (Rogerson, 1998). While improving usability of the machine tool interface would undoubtedly reduce learning time and allow machinists to reach desired levels of production more quickly, it is also reasonable to expect that employing better training methods would aid users in learning to operate the machines.

The intent of this experiment was to study a popular CNC lathe/interface system and provide specific information to answer the following questions concerning the interface and machine tool combination:

Would the train-to-criteria method be an improvement over conventional training methods from the standpoint of training effectiveness reflected in an operator's retention of the knowledge necessary to begin using the CNC interface, and measured by the operator's speed of execution, frequency of accessing help, and error rates?

Would use of a train-to-criteria method help overcome some of the usability problems inherent in a typical CNC interface?

2. Literature Review

2.1 General Background

Although the transition to automation in general industry is not by any means complete, machinists are increasingly being called upon to work with computer controlled equipment. The average machine shop has at least one Computer Numerically Controlled (CNC) lathe, mill, or grinder. On many production floors, CNC machines have supplanted manually controlled tools with the intent of improving quality and reducing production costs by providing greater flexibility of production operations and allowing a single operator to tend multiple machines. While employment for manual machine tool operators is in decline, demand for CNC machine operators is expected to rise as the trend toward automation continues (Occupational Outlook Handbook, 1998).

The adoption of Computer Aided Design (CAD) systems by engineering and design groups leads naturally into more connectivity between the design office and the production floor. While CAD packages (such as MasterCAM) that bridge the gap by generating machine code are already in common use, we are still far from the futurists' vision of lights out factories, run by means of program and instruction uploads from the engineering and management offices. Human operators are still the norm in industry.

Machine tool operators fall into two general categories: those who are responsible for setting up the machines prior to operation, and those who tend to machines during production. The machine operators may or may not be called upon to make minor adjustments in the course of an operation. In many facilities, workers may be required to perform both of these tasks. As a result, they are required to achieve a high level of familiarity with the machines.

In spite of the technological capabilities already attained, it is still the norm to see production facilities using CNC machines programmed by the keystroke at the machine console. Few shops have progressed to the point where human operators are unnecessary. Because of the complex nature of machining tasks, the cost of scrap and wasted labor, and the potential for serious damage to equipment or physical injury, operators must be trained to a sufficient level of proficiency to carry out the desired tasks and meet the productivity demands of the production cycle.

In spite of the increasing complexity of the machining environment, it is not uncommon for CNC machine operators to learn their trade on the job, progressing through increasingly greater levels of task responsibility. Some companies have formalized the training process while others rely on the machine tool manufacturers to supply initial training (Occupational Outlook Handbook, 1998).

Typical CNC operators learn the basics of their jobs within several months. Full mastery of machine operation can take years to achieve. The time required to attain a certain level of competency depends on the individual operator's ability and the complexity of the machine.

2.1.1 CNC Interface Usability

Unfortunately, improvements in the usability of CNC machine controllers, in contrast to consumer computer goods, have not kept pace with those of popular application software (Rogerson, 1998). Some of the most commonly used CNC controllers are still laden with significant usability problems, making the machines difficult and cumbersome to use. Due to poorly defined menu structures, the interfaces encourage the user to operate in a rule-based mode. They also provide the user with little or no feedback. Hidden menu choices and unclear labeling further hinder use of the interfaces (Rogerson, 1998). It is reasonable to expect that the usability deficiencies found in CNC interfaces will lead to difficulties in learning to use the machines and perform machining operations.

2.1.2 Learning

McGehee and Thayer (in McCormick & Tiffin, 1974) described learning as a process wherein behavioral changes occur in response to experience. Learning can also be viewed as a means of formulating a connection between a stimulus acting on an organism and an optimal or appropriate response from the organism. (McCormick & Tiffin, 1974). Many factors such as task complexity, innate ability, motivation, training method and structure of practice, affect an individual's ability to learn a particular skill.

As might be expected, the ability of individuals to benefit from instruction and training differs. Those with greater mental capabilities may be able to assimilate and apply knowledge

more quickly than the norm. The rate of instruction, therefore, should be adjusted to the individual's ability to learn. (Schultz, 1978).

A learner's motivation can also have a profound effect on the absorption of training material. Whether through intrinsic means, such as a worker's pride for a job well done, or through extrinsic means, such as praise, pay, recognition of the need for training, or job security, motivation increases the learning rate. (McCormick & Tiffin, 1974).

Knowledge of results may enhance learning by allowing the operator to adjust his or her actions to obtain the desired results. Early in the learning process, feedback provides a basis for correcting mistakes. Lack of feedback may significantly hinder an operator in attaining a given level of proficiency in certain tasks, namely those in which the operator must know how the system responds in order to properly control it (Travers, 1977). Lack of feedback may also significantly increase the time required to gain proficiency in a task (Stockbridge & Chambers in McCormick & Tiffin, 1974).

Task complexity is yet another factor that affects learning. Complex tasks are naturally more difficult to learn than simple tasks. Increased complexity, as defined by the number of steps required in a task, affects the rate of learning (O'Hara, 1990). In the context of this definition, more complex actions could be viewed as requiring more steps to complete. Gagne (in McCormick & Tiffin, 1974) postulated a hierarchy of learning sequence, which encompasses a continuum ranging from simple stimulus-response connections to the learning of complex principles or rules, each level requiring relevant learning at the lower levels. The strictness of the hierarchy is under debate. The Gagne model may, however, explain the increasing difficulty of learning more complex tasks, such as CNC operation, that involve multiple discriminations, concepts, and simple and complex principles or rules.

Another important consideration in the ability of a person to learn is the frequency, duration, and structure of practice. Although there are no consistent and generally applicable rules for optimal practice scheduling, it has been found that distributing training, particularly in the case of difficult or less meaningful material, is more effective and may lead to longer retention than training carried out in concentrated sessions. (McCormick & Tiffin, 1974).

2.1.3 Individual Differences

Van der Veer (1989) stated that individual differences in cognitive function and style are important considerations when introducing novices to computer systems, and affirmed that the interaction between the new user and the system may be improved if these differences are reflected in the design of both interfaces and training regimens. Individual differences span a continuum encompassing both static and dynamic dimensions (Van der Veer and Van Muylwijk, in Van der Veer 1989). Relatively stable personality features such as intelligence, interpersonal relationship styles, and fear of failure interact with learned traits such as knowledge and skills to influence the learning process and the selection of cognitive styles and learning strategies employed by the student. The learning environment must be structured to address these differences by adjusting to an individual's cognitive style. Such adaptation may take the form of changing the interface to more closely match user characteristics and limitations. More realistically, adaptation in CNC training would consist of modifications to the educational process designed to address individual needs, wishes, abilities, and limitations. Obviously, changes to the training process require more effort from the instructor, and some means of determining the effectiveness of the instruction.

2.1.4 Retention

Once a task is learned, the knowledge acquired must then be retained. Retention may be viewed as the continued capacity to behave in a particular way that has been learned. Retention may also be examined graphically as the quantity of material recalled after some time interval has passed (Travers, 1977).

As with learning, there are several factors that affect the degree to which an individual retains knowledge gained through training. Task complexity and the logical sequence of task elements, both affect the decay of learned skills (O'Hara, 1990).

The quantity and scheduling of practice has a significant impact on retention. More practice leads to more rapid acquisition of skills and a higher degree of retention. There is evidence that carrying on with practice after fluency is achieved, termed overlearning, may significantly aid retention of the skill (Travers, 1977).

The author participated in a program intended to train operators in the use of lathes employing a common CNC controller. The training regimen experienced by the author relied largely on a rule-based approach. Over the span of a five-day week, operator trainees were introduced to the basic procedures necessary to run the CNC machine. The training focused heavily on developing the operator's ability to write and manipulate G- and M-code programs. Far less time was spent learning about the actual operation of the machine and manipulation of the interface. During interface operation training, there was no formal evaluation of knowledge assimilation. Several times during the course (three times in the author's class) the students performed common tasks under the direct supervision of company trainers. The tasks included common procedures such as loading machine programs from the library, and zeroing machine axes. No formal test was performed to determine whether trainees were able to perform the tasks without assistance (Rogerson, 1998).

It cannot be disputed that program writing and editing skills are necessary for those operating CNC machines in most shops. However, effectively training workers in machine interface operation is an area that could have a large impact on immediate productivity and transfer of the skills from the classroom into the work environment. As mentioned above, common CNC interfaces contain numerous significant usability problems that are likely to increase an operator's training requirements and the amount of time required to achieve fluency in operation. If the assimilation of actual operational abilities is not checked as part of training, it is likely that operators will experience significant problems early in occupational machine operation.

To determine whether a training program could benefit by changing from current instructional methods to a train-to-criteria method, it was necessary to compare operators trained using the two methods. Proctor and Van Zandt (1994) advise evaluating training programs based on the degree of knowledge transfer from trainer to operator during training, or the retention of knowledge training produces in operators. This study examined the training methods based on knowledge retention.

2.2 Specific Background for the Experiment

In the design of a retention study, a number of issues must be examined. A review of retention study literature reveals considerations of particular importance:

- Training duration
- Training methods to be used
- Whether or not to train to criteria
- Whether refresher training is provided during the study
- Number of repetitions of tasks studied
- Number and scheduling of experimental sessions
- Whether the operator is supplied with reference materials
- The number of subjects to examine
- Retention metrics to be used

The following sections examine these factors as they are discussed in recent retention study literature.

2.2.1 Training Duration and Repetitions

A primary question in retention study design is that of training duration for each experimental subject group. A survey of recent retention study literature provides no clear answer to this question. Sauer et al (2000) tested the effects of training on short and long term skill retention, providing six hours of procedure-based training, the kind currently used in the CNC training environment, carried out over the course of five sessions.

A second, related question deals with the number of task repetitions during training. According to Hagman (1980b), task repetitions reduced task time and error rates on both immediate and delayed retention tests. Time and error rate were generally found to vary inversely with the number of repetitions performed. Performance differences present in immediate testing were also present in delayed testing.

2.2.2 Training to Criteria

An alternative to the idea of a standard contact time or minimum number of repetitions during training is that of training to some criterion. In several retention studies, Hagman (1983) did not employ training time limits, but trained to the criterion of one successful (error-free) task completion. The US Army uses a training criterion of one complete, error-free task performance carried out within a predetermined time period. (Hagman, 1983).

An obvious advantage inherent in the train-to-criteria method is that all learners are, by definition, brought to some predetermined and consistent level of performance in the course of the training. Without a means of evaluating the effectiveness of instruction, such assurances are not possible. The benefits of evaluating student achievement, namely uniformity of training, and the ability to track the effectiveness of the training program and instructors, may be lost. Because of the variables involved in learning and retention of knowledge, and the diverse abilities of trainees, it is reasonable to expect that the duration of training and practice necessary will vary for individuals. As a result, there may be practical difficulties in scheduling training and predicting the amount of practice and training necessary for a given trainee.

2.2.3 Refresher Training

A question that arises in the study of retention is whether refresher training should be provided between the study trials. In retention studies conducted to examine the effects of training method on retention, Sauer et al (2000) and Hagman (1983) did not employ refresher training between the initial and follow-up sessions. Providing refresher training after the initial examination and prior to subsequent examination may serve to reinforce initial training and skew the results of the retention study (O'Hara, 1990).

2.2.4 Experimental Session Scheduling

Initial experimental sessions in all studies examined were carried out immediately after training to provide a baseline for comparison. Sauer et al (2000), for example, used two experimental testing sessions, each examining the main study effects for an hour. Other retention studies follow this pattern of two experimental sessions. Intermediate sessions, while potentially

providing information on the rate of retention decay, might also supplement the initial training in a manner similar to a refresher session.

In the study conducted by Sauer et al (2000), subjects were examined in two sessions, spaced eight months apart, to explore long term retention. Most retention studies examined concentrated on long term retention, usually on the order of 6 months or more. Studies described by Hagman (1983) examined retention over periods ranging from two weeks to several months.

2.2.5 Operator Reference Materials

In Sauer's study (2000), participants learning to use a control system were provided with a reference guide to use during both training and testing sessions. Those receiving rule-based training were found to consult the guide more frequently than those receiving knowledge-based training, and as training progressed, the instructor intervened only if subjects did not follow the prescribed procedures. No information was given and no questions were answered about the interactions between system parameters. Prescribed procedures were stressed as the most effective way to manage the system.

2.2.6 Type of Training

In completing the conventional CNC training program, Rogerson found interface operation to be presented primarily as a procedure-based approach, relying on teaching operators specific sequences of task elements rather than developing a higher level knowledge of the system's functions.

Group or class size is also a consideration in training design. A smaller group size, or individual instruction, can lead to more individualized attention from the trainer, but this may be offset by the potential for the enhanced group dynamic, social pressure, and additional opportunities for observing task performance inherent in the larger group setting. Guetzkow et al (in Travers, 1977) found evidence that these effects may not be a significant concern. Rogerson noted that, during the training sessions he attended, those waiting to perform tasks just demonstrated did not necessarily follow the progress of the other trainees as they performed the task.

2.2.7 Number of Subjects

In the interface training and retention study conducted by Sauer et al (2000), a between-subjects design, an initial group of 25 participants was employed; 17 of the original participants completed the study. In Hagman's 1983 survey of thirteen Army retention studies, subject population sizes ranged from 6 to 523 with a mean of 50 and a median of 15. The most common subject population size in the retention study literature seems to be between 12 and 15.

2.2.8 Measures of Retention

Retention can be measured in three different ways: free recall, recognition, and the relearning method (Travers, 1977). Free recall requires a subject to retrieve and provide information stored in memory with minimal cues. Recall requires detailed information to be stored. Recognition testing provides the subject with some number of alternatives from which he or she must select the appropriate response. Recognition involves a perceptual analysis and demonstrates that some characteristics of the alternatives have been retained, but does not demonstrate that recall is necessarily possible. The relearning method measures the amount of learning that is necessary to regain a previously attained level of performance after some retention interval has passed.

Rowe et al (1996) identified several methods of assessing operators' understanding of a system, among which were: accuracy and time measures (error rates, task completion times); structured or unstructured interviews; and process tracing or think-aloud methods (Sauer et al 2000). Sauer also suggested using error rate, task performance time, and time spent in error to measure performance. Similarly, studies described by Hagman (1983) used error rates and task performance times to measure retention level. In each of these retention studies, the performance measures, such as error rate, time spent in error mode, and task performance time, were compared between the initial and delayed testing sessions.

3. Variables and Hypotheses

The dependent and four independent variables used in the present study are discussed below as are the hypotheses tested.

3.1 Independent Variables

The independent variables were:

- Training method: two levels, conventional and train-to-criteria
- Training delivery: two levels, subjects examined individually, and in groups of two.
- Trial session: two levels, initial trial and delayed trial
- Subject

From subject to subject, the training method employed was randomly assigned between two levels, the first level being conventional training, similar to that provided by the training facility, and the second level being the train-to-criteria method, in which the operator was trained until a predetermined performance standard was met.

Trial session time was examined at two levels, each subject being examined twice. The initial trial took place immediately following the training session. The second (delayed) trial was conducted approximately two weeks after the training session and first trial.

3.2 Objective Dependent Variables

The objectively measured dependent variables were:

- Overall task time
- Time in error
- The number of errors committed (total, unrecovered, and undetected)
- Time spent in error recovery
- Number of reference consultations and help queries to the analyst

Overall task time was measured using a stopwatch and included time used by the operator to accomplish the required objectives in operating the machine.

The time spent in error was measured with a stopwatch, and included all time from the initial errant activity until the operator recovered from the error state and re-entered the correct task sequence. Time spent in error recovery, a subset of time spent in error, was measured with a stopwatch beginning at the point when it became apparent that the operator recognized an error had been committed, and ending when the error recovery was complete.

The number of errors committed was counted. Errors were considered to be any deviation from the standard procedures or requirements of task performance.

The number of reference consultations and help queries was counted. Any use of the reference material was counted as a consultation, as was any question or help request directed to the analyst.

3.3 Subjective Dependent Variables

Subjectively measured dependent variables were:

- Usability ratings for each step of the task
- Overall usability ratings for the interface

At predetermined times during the course of the task completion, subjects were asked to rate the usability of the interface using the form found in Appendix E, on page 55. The operator was also asked at the conclusion of the experimental session to assign overall usability ratings for the interface using the same form.

3.4 Hypotheses Tested:

1. Compared to the conventional method, the train-to-criteria method improves an operator's retention of knowledge necessary to use the CNC interface.
2. The train-to-criteria method would help overcome some of the usability problems inherent in the CNC interface.

3.5 Table of Variables:

Hypothesis	Dependent measures	Measurement Techniques
1 Compared to the conventional method, training to criteria improves an operator's retention of the knowledge necessary to use the CNC interface.	Number of errors committed	Count of errors committed during task performance
	Number of reference consultations	Count of reference consultations
	Number of help queries	Count of help queries
	Time to complete operations	Stopwatch timing of task elements and overall task time
	Time in error	Stopwatch timing of time in error
	Time in error recovery	Stopwatch timing of time in error recovery
2 Training to criteria would help overcome some usability problems inherent in the CNC interface.	Usability rating for each task step	Rating of usability by operator
	Overall usability rating for the interface	Rating of usability by operator

4. Methodology

4.1 Design of the Study

In this study, the impact of two training methods on an operators' ability to retain knowledge was examined.

Five tasks commonly found in machine operation were used to provide as realistic a sampling of the user's experience with the interface as possible. Further, the users were asked to provide feedback on the interface with respect to all tasks performed. Instructions for the tasks were drawn directly from training and reference materials produced by the lathe manufacturer and used in the training facility (Hardinge, 1996, 1997). The table below lists all tasks studied along with text descriptors that provide an easier means of identification in this paper. For complete descriptions, see Appendix D, page 53.

Table 4.1 Tasks and Descriptors

Task	Descriptor	Activity
1	Home	Power Up and Zero Return
2	Call Program	Activate a Stored Program
3	Collet	Opening/Closing Collet
4	First Part	Make First Part
5	Shut Down	Shutting Down Machine
	All Tasks	Evaluation Across All Tasks

4.1.1 Training Design

Since the scope of the operations and the level of complexity of the machining tasks examined in this study were not as great as those examined by Sauer et al. (2000), it was felt that a shorter training period was appropriate. To further align the present study with actual machine training and use environments, exposure to the tasks in terms of duration and number of repetitions was kept as similar as possible to that experienced by persons being trained in the conventional program, within the constraints of facilities, time and subject availability. Training and reference materials produced by the manufacturer were used.

Due to subject scheduling and time constraints, and experimental facility size, the groups used in the current study were smaller than those typically found in the model training facility (one or two trainees as compared to eight to ten). In the design of the present study, whose purpose was to compare and contrast the conventional training protocol with a train-to-criteria

method, there was some question as to whether the comparatively smaller group size to be used in the study would adversely affect the outcome. As noted in the literature review, there seems to be no definitive evidence that group size significantly influences training effectiveness.

In keeping with conventional training practices, and to maintain a meaningful relationship between this study and the machine use environment, a procedure-based approach was followed in subject training for both groups. Operators were trained by one of the two methods and examined immediately to ascertain the degree of their mastery of the processes learned and provide a basis for comparison (Sauer et al, 2000).

Subjects in the conventional experimental group received an at-the-machine demonstration and then performed three practice trials under the guidance of the analyst. Subjects in the other experimental group were trained to criteria. Based on examination of various retention studies, the criterion of one successful error-free task performance, as used by the US Army (Hagman, 1983), was selected as appropriate for this study. No time criterion was used, however.

4.1.2 Refresher Training

In keeping with standard retention study practices, no practice sessions or refresher training were provided between the experimental sessions.

4.1.3 Experimental Session Scheduling Design

Because common machine operations using the CNC interface were studied, it was decided that retention over a long time period was not a concern in the face of real world application of the results. For the purposes of this study, it was felt that examining retention after two weeks would realistically represent the longest delay likely to be experienced by trainees before applying their knowledge to actual machine operation.

4.1.4 Experimental Use of Reference Materials

Although the conventional training protocol does not limit trainees to procedural methods, it was the author's experience that most participants did not seek knowledge- or system-based information. Rule based behavior is controlled by stored rules or procedures

obtained through experience or instructions, whereas knowledge-based behavior involves problem solving and reasoning that require a much more comprehensive and accurate mental model of the system (Proctor & Van Zandt, 1994). Thus, the conventional training was rule-based rather than knowledge-based. Because such information sources are common in real world applications, and are supplied and used in the conventional training protocol, reference materials used at the training facility were made available to subjects during the study sessions. The references included task sequence listings.

4.1.5 Number of Subjects

Because the study was conducted using a within-subjects design, fewer subjects were necessary than were employed by Sauer et al. Examination of several retention studies indicated that subject group size typically ranges between twelve and fifteen, however, due to supply, this study employed twenty subjects in each trial group, for a total of forty subjects.

4.1.6 Study Design and Data Analysis

The study employed a two by two by two, repeated measures design (training method x delivery x subject trial), with training method and delivery as between-subjects factors, and subject trial as a within-subjects, repeated measures factor. ANOVA was used to determine the presence of significant differences in the dependent variables, performance times, time spent in error mode, and error rates, between the initial examination and delayed testing of retention. Specifics of the analysis procedure are discussed in section 4.7, on page 27.

4.2 Preparation for Experimental Sessions

Subjects for the usability trials were drawn from the student population at Rochester Institute of Technology. A total of forty subjects was examined, each participating in two experimental trials, for a total of eighty trials. Subjects were divided randomly into two subpopulations: those receiving conventional training, and those being trained to criteria, and again into groups receiving training alone or training in pairs.

Subject candidates were pre-screened to conform to the desired subject profile. Since the study was focused on the user interface, acceptable subjects may have had machining experience with manually operated machine tools, but must have had no experience with CNC machine

interfaces, or the specific CNC machine tools and controllers being studied. Subjects were required to be physically able to operate a machine tool and must not have been under the influence of any medications or other substances that could adversely affect their ability to safely operate a machine tool. These qualities were determined by questionnaire and observation. Candidates were required to commit to both of the experimental sessions and were required to sign an informed consent form (Appendix B, page 49).

Candidates were requested to make appointments for their sessions. Each candidate was informed of the general nature of the study and requirements for participation, and informed that he or she would be required to participate in two sessions, over the period of approximately two weeks, the first requiring approximately one hour, the second approximately fifteen minutes, if he or she was selected to participate in the study.

Upon appearing for the initial session, candidates were assigned a numerical code number that was used to identify data and records. Information linking personal information and code numbers was maintained securely by the principal investigator and destroyed at the conclusion of the study. Each candidate was informally interviewed about his or her machine operating background to verify that he or she met the criteria for participation. Candidates were given a written description of the experiment (see appendix A, page 48). The experiment was explained verbally, and candidates were given a chance to ask questions. Each candidate was informed that he or she might choose to terminate participation at any time or for any reason during the course of the study. Candidates that met the criteria and wished to participate in the study were selected as subjects.

Upon qualifying and agreeing to participate, subjects were asked to sign an informed consent form as required by RIT. The informed consent form can be found in appendix B (page 49). After the informed consent form was completed, subjects were given a brief demographic survey, found in appendix C (page 51), to obtain more detailed information about their backgrounds and to collect information concerning any external factors that could adversely affect performance in a cognitive task. The survey also inquired about subjects' machining experience and any experience with the CNC interfaces being studied.

When subjects had completed the above portions of the screening process, the analyst reviewed the responses to confirm that the following requirements for participation had been met:

- Subjects should have had minimal machining experience.
- Subjects must have had no experience with the controller being studied or similar CNC machine controllers.
- Subjects must have had no factors that would interfere with their ability to safely operate the machine or properly follow directions.

If these criteria were met, the first experimental session began.

4.3 Experimental Session Procedure

Prior to the start of the session, the analyst randomly drew the subject's experimental group assignment. Video tapes were labeled with the subject code. The analyst loaded the video tapes, started the video recording equipment and verified correct operation.

Subjects first received hands-on training to familiarize them with the machine interface and the procedure they were to perform. Subjects received reference materials to consult while operating the interface. The training presented each task in a form identical to that used in the experimental trials. For conventionally trained subjects, training was made as similar as possible to that used by the training facility in the sessions attended by Rogerson. For criteria-trained subjects, training was provided to meet the criterion of one error-free, unassisted performance of the task. Specific task listings can be found in appendix D on page 53. During the training phase, subjects were encouraged to ask questions and comment on any points of confusion.

The initial experimental trial took place immediately following the training. The subject was supplied with the reference materials used during the training phase, and was instructed to perform each task sequence. During performance of the task, subjects were free to consult the reference materials or ask the analyst for additional information. If additional information was required, the analyst asked questions to obtain information about the cause of confusion. If the subject performed an incorrect action, the analyst tried to determine the cause of the error, and , if necessary, gave instructions to assist the subject in error recovery. If recovery could not be achieved reasonably, the analyst intervened and performed error recovery steps for the subject.

At the conclusion of each task, the analyst asked the subject about any particular problem areas and administered an interface assessment questionnaire (see appendix E, page 55), based on the modified Cooper-Harper scale. (Cooper & Harper, 1969 in Proctor & Van Zandt, 1994). Subjects were permitted to ask any questions they had regarding the machine interface or the experiment. At the conclusion of the experimental session, a final questionnaire was administered to obtain information about the subjects' perception of the interface as a whole. Subjects were scheduled to return for a second experimental trial two weeks later. The second session closely followed the above procedure.

4.4 Timeline

Subject trials began as soon as potential subjects were identified and scheduled. Since forty subjects were examined and each subject required approximately one and a half hours to be examined, the total time for experimental runs was approximately sixty hours over four weeks. The experimental trials were spaced as close as possible to two weeks apart.

4.5 Hardware and Software Requirements

Each experimental session was recorded on video tape. Camera location was chosen to permit a clear view of the control panels and all relevant activities performed by the subject while obtaining adequate sound quality for analysis. A CNC lathe/controller, located in the Brinkman Machine Tools Lab at Rochester Institute of Technology was used during all subject trials. The study used forty subjects for a total of approximately one and a half hours each, in two sessions. No special software was required. Statistical analysis was performed using Minitab release 12.0.

4.6 Space Requirements

Experimental trials were conducted in the Brinkman Machine Tools Lab on the RIT campus.

4.7 Data Analysis Procedure

Following the two experimental trials, the results of the questionnaires were compiled in an Excel spreadsheet to generate an overall summary of responses for each phase of the two machine operation tasks, and for the overall assessment of the interface.

Videotapes were analyzed using stopwatch timing to determine subtask performance times, time spent in error, and recovery time. Errors and consultations with the reference card and requests for help were counted and totaled for each subtask to determine help request and error rates. Comments and questions from the subject were compiled to provide information on the specific impressions of users.

After reduction, data sets were tabulated by method, delivery and run to allow an informal, qualitative examination of trends and informal comparison of means by factor. Using Minitab, a box plot was generated for each data set to allow a graphic examination and comparison of the data by factor.

The experimental design was translated into a Minitab General Linear Model with the following configuration:

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'Queries' = Method|Delivery|Run Subject(Method Delivery);
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Factor	Type	Levels	Values
Method	fixed	2	criteria, baseline
Delivery	fixed	2	multiple, single
Run	fixed	2	run 1, run 2
Subject(Method Delivery)	random	40	subjects s1-s20 and c1-c20

Data such as time values that were expected to conform to a normal distribution were subjected to a 2 X 2 X 2 analysis of variance with repeated measures on subjects (Winer, 1971). Residuals were checked for normality using normal probability plots and histograms. Data not conforming to a normal distribution were examined using a contingency table and chi-square analysis to determine whether there were any significant dependencies between runs or training methods.

5. Results

5.1 Population Data

T-tests were performed on subject subpopulation pre-test data (age, education and retention period duration) to determine equivalence between training method (conventional vs. criteria) and training delivery (single vs. multiple) subpopulations. At an alpha value of 0.05, no significant differences were identified between the populations in any of these variables, so differences in performance detected by the experiment can be reasonably attributed to manipulation of the independent variables. Subject population specifics and detailed results of comparisons can be found in Appendix K, beginning on page 122.

The subjects in this experiment were drawn from a largely technical population with all subjects having a significant background in computer use. The gender breakdown, 72.5% male, 27.5% female is reflective of the overall population from which the candidates were drawn. Similarly, the age breakdown is indicative of the population from which subjects were drawn. Subjects ranged in age from 19 to 45 years. The mean subject age, 21.55 years (SD=3.948), is in close agreement with the median age, 21 years, and the mode, 21 years. In the author's experience, some seasoned machine operators tend to be less accepting of new technologies and changes in the manner in which they do their jobs than the students comprising the subject population. In this light, the resulting data from the student population can therefore be viewed as a best case scenario for acceptance of the unfamiliar technology and assimilation of training. Experience with other CNC machines and interfaces may of course contribute to greater acceptance of the interface and training in some seasoned operators within the actual user population.

Subjects all had similar educational backgrounds. All but two of the subjects were recruited from the undergraduate engineering and information technology student body at the university. Two subjects were taken from the general population and reported holding graduate degrees. Since all of the subjects had backgrounds that included some form of computer and/or technical training, it is reasonable to assume that they were comfortable with the type of training encountered in the experiment. Informal observation bore this out.

Although the target retention period was fourteen days, actual periods ranged from ten to seventeen days with a mean of 13.75 days (SD=1.35). The median and mode values, however are

both fourteen, suggesting that actual conditions closely approached the target. Scheduling difficulties and unreliability inherent in using a student subject population were the primary causes of the irregularities.

As a basis of comparison, conventionally trained subjects were allowed three repetitions of each task. This number was selected to reflect the regimen experienced by the author during training at the training facility. Subjects trained to criteria required from three to six trials, with a mean of 4.55 trials (SD=0.759) to achieve fluency in the operations. A 95% confidence interval around this mean verifies that this number differs significantly from the three trials given to conventionally trained subjects.

5.2 Time Data and Usability Results

Time data and usability questionnaire responses using the Cooper-Harper scale were analyzed using a 2x2x2 ANOVA (training method x training delivery x trial) with repeated measures on trial. Results of the ANOVAs were evaluated for significance at $\alpha=0.01$ and $\alpha=0.05$. Complete summary tables and listings of the ANOVA outputs are presented in Appendices H (objective data), and J (subjective data) commencing on pages 77 and 109 respectively. A listing of time, usability, and count results follows in Table 5.1 (significance is indicated for alpha values of 0.01, 0.05, and 0.10).

Residuals were plotted using histograms and normal probability plots to check for normality. These tests confirmed normality for overall time in all five tasks. Normality was also confirmed for usability in all tasks with the exception of error recovery in the Collet task. Due to the limited quantity of recovery time and time in error data returned, these variables were not analyzed.

For all data, tabulations were performed for initial organization of the data and to allow a preliminary view of potential relationships among the variables. Tabulations included mean values for each data category. Boxplots were also constructed to provide an additional means for visual examination of data spread within individual categories. Tabulations and boxplots can be found in Appendices F and I (beginning on pages 56 and 80 respectively).

5.2.1 Time Data

Significant differences in task time between training methods were identified for two of the five task sequences: First Part ($F=15.50$, $p=0.000$) and Shut Down ($F=7.45$, $p=0.010$). In these two tasks, the subjects trained to criteria exhibited superior performance. A significant training delivery effect ($F= 4.95$, $p=0.033$) also existed for Home, indicating that subjects trained in groups required less time to perform the necessary operations.

Table 5.1: Summary of Results

(Cr=Criteria, Co=Conventional; S=Single, M=Multiple; T1=Initial Trial, T2=Delayed Trial; ***significant at α=0.01, ** significant at α=0.05, * significant at α=0.10)

Dependent Measures	Method Effects	Delivery Effects	Run Effects	Interactions			
				M x D	M x R	D x R	M x D x R
Total Task Time							
Home	Cr<Co, F=3.48, p=0.070*	**M<S, F=4.95, p=0.033****	**T1<T2, F=39.48, p=0.000*****	F=1.77, p=0.191	F=1.27. p=0.268	F=1.78, p=0.190	F=0.84, p=0.36
Call Program	Cr<Co, F=1.94, p=0.172	M<S, F=1.94, p=0.172	**T1<T2, F=60.72, p=0.000*****	F=0.65, p=0.427	F=0.01, p=0.943	F=0.00, p=0.964	F=0.86, p=0.36
Collet	Cr<Co, F=3.51, p=0.069*	M<S, F=1.03, p=0.317	**T1<T2, F=29.99, p=0.000*****	F=0.24, p=0.629	F=1.08, p=0.305	F=0.06, p=0.800	F=0.31, p=0.58
First Part	**Cr<Co, F=15.5, p=0.00*****	M<S, F=1.05, p=0.312	**T1<T2, F=65.66, p=0.000*****	F=0.47, p=0.495	F=2.35, p=0.134	F=0.50, p=0.483	F=0.03, p=0.86
Shut Down	**Cr<Co, F=7.45, p=0.01*****	M<S, F=2.34, p=0.135	**T1<T2, F=68.72, p=0.000*****	F=0.17, p=0.679	F=1.38, p=0.247	F=0.23, p=0.637	F=1.46, p=0.23
Usability Measures							
-Control & Label Clarity							
Home	Cr<Co, F=1.01, p=0.323	M<S, F=0.05, p=0.818	T1<T2, F=1.51, p=0.227	F=1.01, p=0.323	F=0.44, p=0.512	F=0.01, p=0.925	F=1.08, p=0.305
Call Program	Cr<Co, F=1.08, p=0.307	S<M, F=0.20, p=0.659	**T1<T2, F=28.47, p=0.000*****	F=0.02, p=0.883	F=2.12, p=0.154	F=0.24, p=0.631	F=0.24, p=0.631
Collet	Inconclusive F=0.00, p=1.0	S<M, F=0.10, p=0.759	T1<T2. F=1.69, p=0.202	F=0.86, p=0.359	F=0.75, p=0.392	F=0.19, p=0.668	F=0.75, p=0.392
First Part	Cr<Co, F=1.38, p=0.247	S<M, F=0.56, p=0.459	T1<T2, F=0.04, p=0.839	F=0.05, p=0.832	F=0.00, p=1.000	F=1.50, p=0.228	**F=5.05, p=0.031****
Shut Down	Cr<Co, F=1.62, p=0.211	S<M, F=0.01, p=0.933	T1<T2, F=1.26, p=0.268	F=0.06, p=0.800	**F=4.51, p=0.041****	F=1.89, p=0.178	F=1.89, p=0.178
All Tasks	**Cr<Co, F=4.60, p=0.039****	M<S, F=0.07, p=0.786	T1<T2, F=0.28, p=0.603	F=0.26, p=0.615	F=1.63, p=0.211	F=1.63, p=0.211	F=0.28, p=0.603
-Menu Structure Clarity							
Home	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Call Program	Cr<Co, F=1.52, p=0.225	M<S, F=0.15, p=0.704	**T1<T2, F=6.14, p=0.019****	F=0.53, p=0.472	F=0.10, p=0.755	F=0.01, p=0.905	F=0.04, p=0.851
Collet	n/a	n/a	n/a	n/a	n/a	n/a	n/a
First Part	**Cr<Co, F=4.67, p=0.037****	M<S, F=0.02, p=0.879	**T1<T2, F=6.32, p=0.017****	F=2.19, p=0.147	F=1.10, p=0.301	F=0.54, p=0.469	**F=5.10, p=0.030****
Shut Down	n/a	n/a	n/a	n/a	n/a	n/a	n/a
All Tasks	Cr<Co, F=1.79, p=0.189	M<S, F=0.01, p=0.933	T2<T1, F=0.01, p=0.924	F=1.56, p=0.219	F=0.18, p=0.675	F=0.25, p=0.623	F=1.84, p=0.184
-Screen & Soft Key Clarity							
Home	Cr<Co, F=0.40, p=0.533	S<M, F=2.73, p=0.108	T1<T2, F=0.03, p=0.866	**F=5.14, p=0.030****	F=0.00, p=0.966	F=0.07, p=0.800	F=0.22. p=0.642
Call Program	Cr<Co, F=1.26, p=0.269	S<M, F=0.67, p=0.417	**T1<T2 F=4.61, p=0.039****	F=0.07, p=0.800	F=0.05, p=0.818	F=0.05, p=0.818	F=2.46, p=0.127
Collet	n/a	n/a	n/a	n/a	n/a	n/a	n/a
First Part	**Cr<Co, F=4.18, p=0.048****	S<M, F=0.36, p=0.551	**T1<T2, F=7.07, p=0.012****	F=0.71, p=0.405	F=2.86, p=0.099*	F=1.46, p=0.235	F=0.53, p=0.473
Shut Down	Cr<Co, F=1.68, p=0.206	S<M, F=1.73, p=0.200	T1<T2, F=0.49, p=0.491	F=0.15, p=0.703	F=0.49, p=0.491	F=0.93, p=0.348	F=0.93, p=0.348
All Tasks	Cr<Co, F=0.97, p=0.331	S<M, F=0.89, p=0.351	T2<T1, F=0.33, p=0.567	F=0.01, p=0.930	F=0.69, p=0.412	F=0.06, p=0.812	F=0.27, p=0.605
-Error Recovery Ease							
Home	Cr<Co, F=2.61, p=0.115	M<S, F=0.02, p=0.882	T1<T2, F=0.55, p=0.474	F=1.36, p=0.251	F=0.43, p=0.522	F=3.16, p=0.101	F=0.55, p=0.474
Call Program	Cr<Co, F=3.85, p=0.060*	M<S, F=0.11, p=0.738	T1<T2, F=0.02, p=0.893	F=1.11, p=0.300	F=3.21, p=0.104	F=0.93, p=0.358	F=0.47, p=0.507
Collet Open/Close	**Cr<Co, F=5.37, p=0.037****	M<S, F=0.46, p=0.510	T2<T1, F=1.42, p=0.268	F=2.55, p=0.133	F=0.26, p=0.623	F=0.26, p=0.623	F=1.42, p=0.268
First Part	**Cr<Co, F=15.42, p=0.00*****	M<S, F=0.39, p=0.536	T1<T2, F=0.52, p=0.483	F=0.29, p=0.592	**F=5.20 p=0.042****	F=1.12, p=0.311	F=1.64, p=0.225
Shut Down	**Cr<Co, F=5.36, p=0.034****	M<S, F=0.00, p=0.997	T2<T1, F=3.22, p=0.103	F=0.95, p=0.345	**F=14.8,p=0.003*****	F=1.64, p=0.229	F=1.64, p=0.229
All Tasks	**Cr<Co,F=11.86,p=0.001*****	S<M, F=0.63, p=0.433	T1<T2, F=0.01, p=0.944	F=0.06, p=0.813	F=0.18, p=0.676	F=1.51, p=0.236	F=0.01, p=0.944

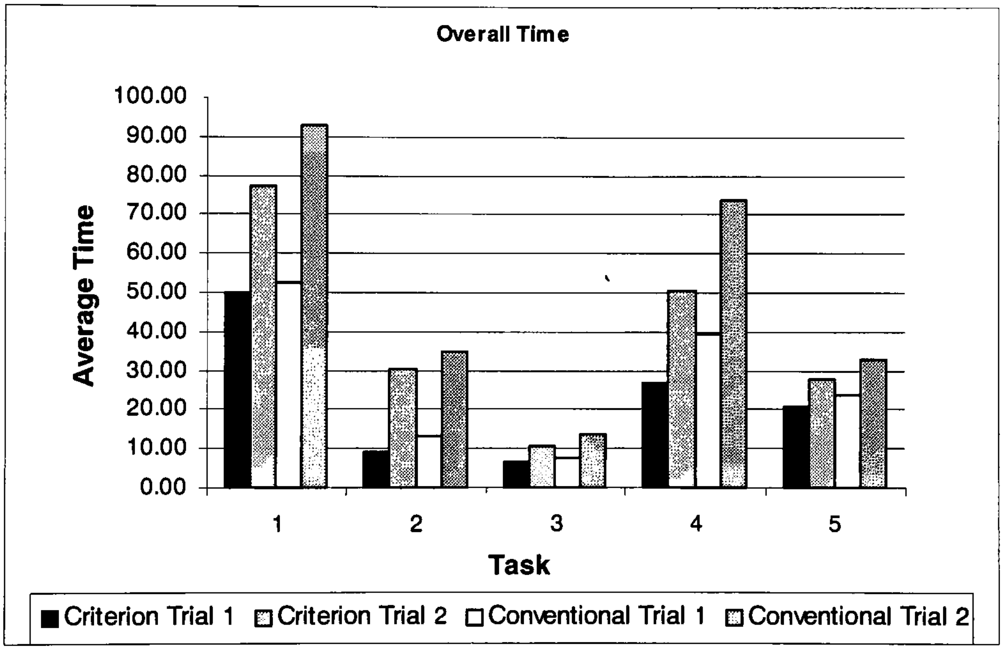
Dependent Measures	Method Effects	Delivery Effects	Run Effects	Interactions			
				M x D	M x R	D x R	M x D x R
<u>Multi-function Key Use</u>							
Home	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Call Program	Cr<Co, F=1.11, p=0.300	S<M, F=0.17, p=0.684	**T1<T2, F=6.00, p=0.022****	F=0.01, p=0.943	F=0.69, p=0.415	F=0.69, p=0.415	F=0.02, p=0.88
Collet	n/a	n/a	n/a	n/a	n/a	n/a	n/a
First Part	Cr<Co, F=2.65, p=0.112	M<S, F=0.14, p=0.706	T1<T2, F=0.58, p=0.451	F=0.00, p=0.988	F=1.14, p=0.294	F=1.88, p=0.179	F=0.21, p=0.65
Shut Down	n/a	n/a	n/a	n/a	n/a	n/a	n/a
All Tasks	Cr<Co, F=0.27, p=0.609	M<S, F=0.06, p=0.814	T1<T2, F=0.48, p=0.494	F=1.04, p=0.315	F=0.04, p=0.845	F=0.48, p=0.494	F=0.04, p=0.84
<u>Overall Impression</u>							
Home	Cr<Co, F=0.33, p=0.566	M<S, F=0.01, p=0.936	T1<T2, F=1.39, p=0.247	F=0.55, p=0.462	F=0.56, p=0.458	F=0.10, p=0.750	F=0.01, p=0.91
Call Program	Cr<Co, F=1.52, p=0.226	S<M, F=0.17, p=0.684	**T1<T2, F=16.30, p=0.000*****	F=0.06, p=0.807	F=0.23, p=0.631	F=0.65, p=0.425	F=0.03, p=0.87
Collet	Inconclusive F=0.00, p=1.00	S<M, F=0.29, p=0.593	**T1<T2, F=4.35, p=0.044****	F=0.03, p=0.858	F=1.09, p=0.304	F=0.07, p=0.796	F=0.61, p=0.439
First Part	**Cr<Co, F=5.16, p=0.029****	S<M, F=0.34, p=0.563	T1<T2, F=1.52, p=0.226	F=0.11, p=0.747	F=0.01, p=0.911	F=2.12, p=0.154	F=1.02, p=0.320
Shut Down	Cr<Co, F=1.80, p=0.188	S<M, F=0.20, p=0.657	**T1<T2, F=4.59, p=0.034****	F=0.39, p=0.535	**F=8.54, p=0.006*****	F=0.04, p=0.847	F=0.95, p=0.336
All Tasks	Cr<Co, F=2.93, p=0.096*	S<M, F=0.62, p=0.436	T1<T2, F=0.36, p=0.553	F=0.00, p=0.985	F=2.86, p=0.100*	F=2.86, p=0.100*	F=0.36, p=0.553
Count Data	**χ^2 Statistic**	**Method Effects**	**Run Effects**				
Query Counts							
Call	**χ^2=5.007 ****	**Criteria<Conventional**	**Trial 1<Trial 2**				
Collet	χ^2=0.420	Independent	Independent				
First Part	**χ^2=18.642 ****	**Criteria<Conventional**	**Trial 1<Trial 2**				
Home/Shut Down Pooled	**χ^2=10.344****	**Criteria<Conventional**	**Trial 1<Trial 2**				
All Tasks Pooled	**χ^2=35.40****	**Criteria<Conventional**	**Trial 1<Trial 2**				
Total Error Counts							
Call Program	χ^2=0.573	Independent	Independent				
Collet	Invalid Test	Invalid Test	Invalid Test				
First Part	χ^2=0.122	Independent	Independent				
Home/Shut Down Pooled	χ^2=0.754	Independent	Independent				
All Tasks Pooled	χ^2=0.802	Independent	Independent				
Undetected Error Counts							
Call Program	χ^2=1.028	Independent	Independent				
Collet	Invalid Test	Invalid Test	Invalid Test				
First Part	χ^2=0.607	Independent	Independent				
Home/Shut Down Pooled	χ^2=1.003	Independent	Independent				
All Tasks Pooled	χ^2=1.252	Independent	Independent				

Note: in the usability measures, a lower score indicates superior usability characteristics

The ANOVA output for the overall task time data for each task confirmed the existence of significant differences ($F \geq 29.99$, $p < 0.005$) between initial and delayed trials, with delayed trial times being higher than those registered for the initial trial.

Figure 5.1 (below) shows these results graphically. Training effects follow a similar trend in all of the tasks, as evidenced by lower average task times returned by the criteria-trained subjects in each of the trials for every task. It can also be seen that delayed trial times are greater than initial trial times for each group.

Figure 5.1 Task Time vs. Training Method by Task and Run

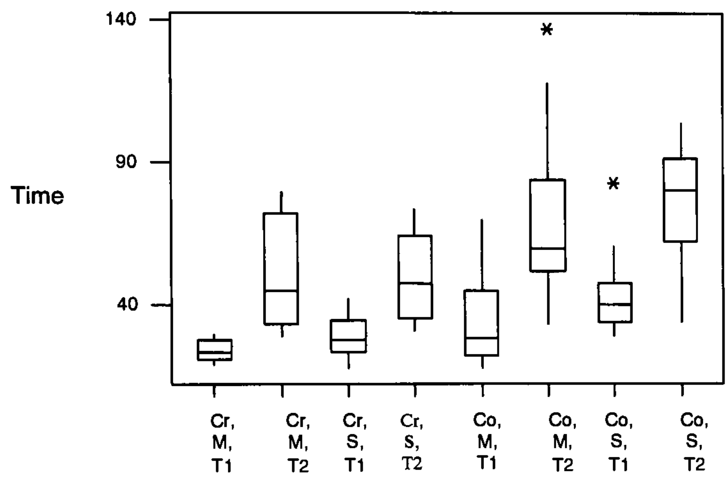


The training method and run effects are also visible in a box plot (see figure 5.2 below). In the case of the time plot for First Part, it can be seen that mean trial times (indicated by the horizontal bars within the boxes) for trial two are higher than those for trial one. A wider dispersion of trial two time values is also evident in the plots. Similarly, comparison of mean times for criteria-trained subjects shows lower average execution times and narrower dispersion for trial one.

Figure 5.2 Boxplot of Time vs. Method, Delivery, Run:

Task 4. First Part

(Cr=criteria, Co=Conventional, M=multiple, S=single, T1=Trial 1, T2=Trial 2)



5.2.2 Usability Data

As mentioned above, data for each of the six questions was analyzed by ANOVA. The questions are shown in table 5.2 along with identifying descriptors.

Table 5.2: Usability Questions and Descriptors

Question	Descriptor	Question Text
1	Control & Label Clarity	How would you rate the interface with respect to the ease of finding the correct switch, knob, or button and understanding the labeling?
2	Menu Structure Clarity	How would you rate the interface with respect to ease of understanding menu structure?
3	Screen & Soft Key Clarity	How would you rate the interface with respect to the ease of understanding the screen displays and finding the correct soft key or data display?
4	Error Recovery Ease	If you made errors during the operation of the interface, how would you rate the ease of making corrections or recovering from the error?
5	Multi-function Key Use	How would you rate the usability of the interface with respect to the ease of using multi-function keys?
6	Overall Impression	Overall, how would you rate the usability of the interface with respect to ease of operation?

When subjects were asked to evaluate the interface with respect to control and label clarity (the ease of finding the correct switch, knob, or button and understanding the labeling), ANOVA results confirmed a significant (F=4.60, p=0.039) training method effect on the All Tasks evaluation, indicating that subjects trained to criteria rated the interface as more usable overall. A strong (F=28.47, p=0.000) run effect indicating lower usability ratings on the initial trial was present in Call Program.

Unexpectedly, there were two significant interactions detected on First Part and Shut Down, tasks not exhibiting significant main effects (the interaction plots can be found in Appendix J, beginning on page 109). ANOVA identified a significant (F=5.05, p=0.031) three-way method-delivery-run interaction for First Part. In this interaction, both conventionally- and criteria-trained subject ratings increased from trial one to trial two, with conventionally trained subjects returning higher average ratings. Group trained subjects increased their average usability ratings from trial one to trial two, while individually trained subjects decreased their average ratings. Both conventionally- and criteria-trained subjects who were trained individually returned lower average ratings than their group trained counterparts.

The ANOVA for Shut Down returned a significant (F=4.51, p=0.041) method-run interaction in which conventionally trained subjects increased their average usability ratings from trial one to trial two. Criteria-trained subjects, conversely, slightly decreased their average ratings.

When subjects were asked to rate the clarity of the menu structure, a query which applied to only Call Program, First Part and All Tasks, ANOVA confirmed a significant training method effect was present (F=4.67, p=0.037) for First Part, with criteria-trained subjects reporting better usability scores. In addition to the main effect for this task, a significant (F=5.10, p=0.030) three-way method-delivery-run interaction was discovered. In this interaction, usability ratings increased from the initial trial to the delayed trial, with conventionally- and individually-trained subjects returning higher ratings than the criteria- and group-trained subjects. Subjects trained individually by the conventional method returned higher ratings than those trained in groups. Conversely, when trained to criteria, subjects who were trained individually reported lower ratings than those trained in groups.

Significant run effects favoring trial one were identified in Call Program (F=6.14, p=0.019) and First Part (F=6.32, p=0.017).

The third point on which subjects were asked to evaluate the interface was on the ease of understanding the screen displays and finding the correct soft key or data display.

ANOVA detected a significant (F=4.18, p=0.048) training method effect in the First Part data for this assessment point, confirming that criteria-trained operators reported greater ease of understanding. Significant run effects favoring the initial trial were detected in First Part (F=4.61, p=0.039) and Call Program data (F=7.07, p=0.012).

A significant method-delivery interaction was identified (F=5.14, p=0.030) in Home. This interaction suggested that subjects trained individually by conventional methods reported higher usability ratings than those trained in groups. Conversely, subjects trained individually to criteria reported slightly lower ratings than those trained in groups. In the initial trial, conventionally-trained subjects reported higher average ratings than criteria-trained subjects.

Subjects who committed errors while performing the tasks were asked to rate the ease of making corrections or recovering from the error. Responses to this question provided strong evidence of training method effects favoring criteria-trained subjects. Three of the five tasks returned highly significant F-values: Collet, F=5.37 (p=0.037); First Part, F=15.42 (p=0.000); and Shut Down, F=5.36 (p=0.034). All Tasks also confirmed the superior performance of the criteria-trained subjects when asked about error recovery (F=11.86, p=0.001). Significant two-way method-run interactions were identified for First Part (F=5.20, p=0.042) and Shut Down (F=14.80, p=0.003). Plots of these interactions are shown below in figures 5.3 and 5.4. In the former, criteria-trained subjects reported lower average ratings for both trials, and both groups reported lower ratings in the initial trial. In the latter task, criteria-trained subjects again returned lower ratings than conventionally-trained subjects, however, both groups reported lower ratings in trial two. These were the only significant interactions appearing in metrics with significant method effects.

Figure 5.3 First Part Interaction

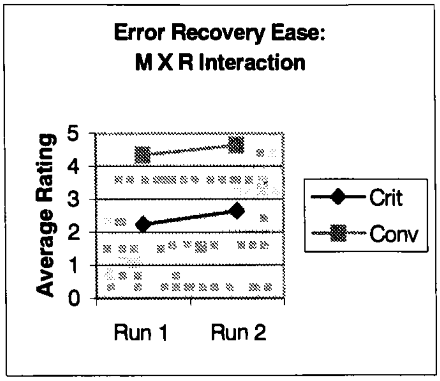
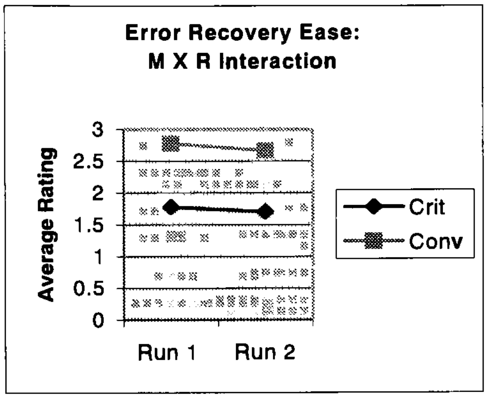


Figure 5.4 Shut Down Interaction

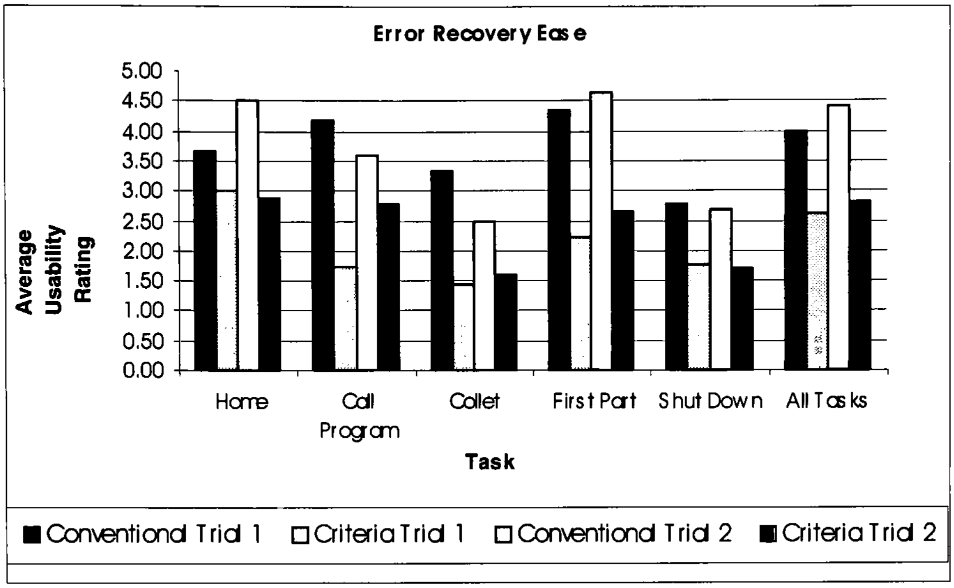


Multi-function keys were used in only two tasks, Call Program and First Part, and were evaluated for All Tasks. A significant run effect (F=6.00, p=0.022) favoring trial one was found in Call Program.

Subjects were finally asked to rate the usability of the interface with respect to their overall impression of ease of operation. ANOVA confirmed a significant training method effect in First Part (F=5.16, p=0.029). Subjects trained to criteria reported a better impression of the usability of the interface than those trained using the conventional method. Significant run effects, all of which favored trial one, were identified in Call Program (F=16.30, p=0.000), Collet (F=4.35, p=0.044), and Shut Down (F=4.59, p=0.034). A single significant (F=8.54, p=0.006) method-run interaction was detected in the power down results. In this interaction, criteria- and conventionally-trained subjects reported an equal rating of usability for trial one. The average rating returned by criteria-trained subjects for run two decreased, however, while the rating for conventionally trained subjects increased.

Tabulation results were mixed, but generally suggested the presence of training method and run effects. The strongest cluster of significant training method effects in the usability data is shown below in the graph of error recovery ease (Figure 5.5). The plot shows the presence of training method effects in all tasks, with subjects trained to criteria reporting better usability. It is interesting to note that the delayed trial results for criteria trained subjects are better than the initial trial results for conventionally trained subjects.

Figure 5.5 Perceived Error Recovery Ease vs. Training Method by Task and Run



Note: a lower rating indicates better usability

5.3 Query and Error Count Data

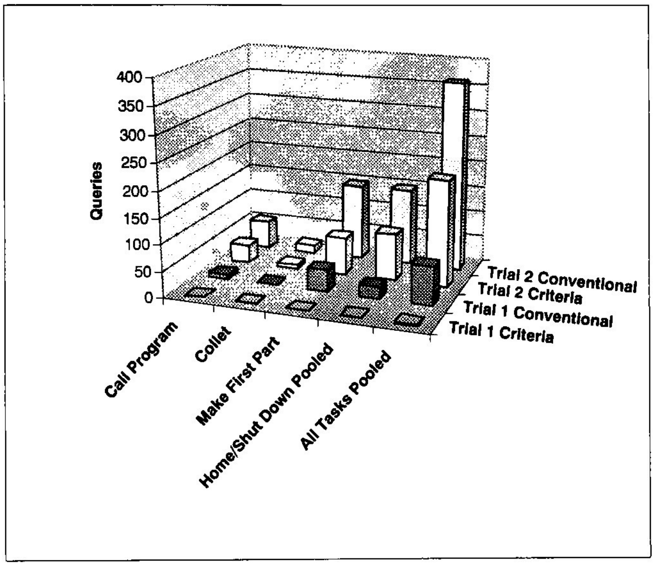
Query count and error count data were analyzed using chi-square. Since sample sizes were small, query and error data was pooled for the Home and Shut Down tasks, and then for all five tasks. Chi square test output can be found in Appendix G on page 75. Complete results of query and error count analysis are summarized in table 5.1, on page 31. Significant results are summarized in Table 5.3 below. Complete output from the chi-square analyses can be found in Appendix G, beginning on page 75.

Table 5.3: Count Data-Summary of Significant Effects
(**significant at α=0.05, * significant at α=0.10)

Dependent Measures	χ^2 Statistic	Method Effects	Run Effects
Query Counts			
Call	χ^2=5.007**	Criteria<Conventional	Trial 1<Trial 2
Collett	χ^2=0.42	Not Significant	Not Significant
First Part	χ^2=18.642**	Criteria<Conventional	Trial 1<Trial 2
Home/Shut Down Pooled	χ^2=10.344**	Criteria<Conventional	Trial 1<Trial 2
All Tasks Pooled	χ^2=35.40**	Criteria<Conventional	Trial 1<Trial 2

Statistically significant differences in query count data favoring criteria-trained subjects and trial one were identified for all tasks except Collet (see figure 5.6). Values for the χ^2 statistics ranged from 4.452 to 35.40, all significant at α values less than 0.05. As expected in the pooled analyses, statistically significant differences were identified for both training method and run. Again the results showed subjects trained to criteria displayed better performance, but still showed decreased performance in terms of the number of help queries in the delayed trial.

Figure 5.6 Query Counts vs. Task, Run, and Training Method



It should be noted in Figure 5.6 that when compared to the effects of training method, the run effects are considerable.

Although there were weak indications of treatment effects in the tabulations and box plots, the error count data provided no statistically significant results.

6. Conclusions and Discussion of Results

6.1 Evaluation of Results

The objective of the experiment was to answer two fundamental questions concerning the two training methods for CNC operators:

- Would the train-to-criteria method be an improvement over conventional training methods from the standpoint of training effectiveness reflected in an operator's retention of the knowledge necessary to begin using the CNC interface, and measured by the operator's speed of execution, frequency of accessing help, and error rates?
- Would use of a train-to-criteria method help overcome some of the usability problems inherent in the CNC interface?

If the train-to-criteria method is in fact superior to the conventional method, one would expect to see the effects manifested in lower execution times, fewer help requests and lower error rates. Better training should also lead to quicker recovery times and a related decrease in the time spent in error modes. Examination of the task time data by ANOVA confirms statistically significant differences between the two training regimes in two of the tasks examined: First Part and Shut Down. In these tasks, subjects trained to criteria required less time to perform the necessary operations. Although no statistically significant differences were detected in the other operations, data tabulations and boxplots of the overall task time data suggest similar effects of training on overall task time may have been present in the other three tasks.

As expected, due to the decay of knowledge over time, significant run effects were confirmed for total task time in all five tasks: the times for the initial trials were lower than those for the delayed trials.

While data sets for recovery time and time in error were too small for rigorous analysis, preliminary examination of tabulations showed weak indications of a training method effect, further supporting the superiority of criteria training, a result also confirmed by usability data.

.The superiority of the train-to-criteria method was also supported by chi-square tests of query count data, which revealed the presence of method and run effects in all tasks except

Collet. Criteria-trained subjects performed better than conventionally-trained subjects, requiring less assistance from help sources. A run effect was present in the Query count data, where counts were lower in the initial trial than in the delayed trial.

Overall, these results indicate that a train-to-criteria method would in fact constitute an improvement over the conventional method, and further, suggest that subjects require more exposure to the comprehensive interface operation tasks than is provided by conventional training. It must be noted, however, that run effects are strongly present throughout these results, including those for subjects trained to criteria. These findings indicate that, although training to criteria represents an improvement over current methods, a change in the training regimen is not sufficient to address the usability problems inherent in the interface .

As was the case with the time data, usability data favored the train-to-criteria method over the conventional protocol, suggesting that the train to criteria method would indeed help to overcome some of the usability problems exhibited in the user interface. Interestingly, this difference appears prominently in the most complex task (First Part), and in the most comprehensive usability evaluations (All Tasks).

In the most comprehensive task, First Part, significant differences appear in four of the usability rating categories for the First Part task: Menu Structure Clarity, Screen and Soft Key Clarity, Error Recovery Ease, and Overall Impression. In each case, criteria-trained subjects reported better usability ratings. In the most comprehensive evaluation (All Tasks), subjects rated the overall usability of the interface across all of the operations performed. Significant differences were detected in two of the usability rating categories: Control and Label Clarity, and Error Recovery Ease. Criteria-trained subjects reported better usability ratings in these evaluations as well. In fact, the delayed trial usability ratings given by subjects trained to criteria were better than those reported by conventionally trained subjects during the initial trial, a finding that supports the superiority of training to criteria.

While usability data for each category (Control and Label Clarity, Menu Structure Clarity, Screen and Soft Key Clarity, and Overall Impression) exhibited significant differences in perceived usability, the greatest number of significant differences came in Error Recovery Ease. Criteria-trained subjects reported greater ease of error recovery in four of the six task rating opportunities for that evaluation category.

It should be noted, however, that in First Part and Shut Down, significant interactions between method and run were present in Error Recovery Ease data. Examination of the interaction graph for First Part (figure 5.3 on page 37) confirms that subjects trained to criteria reported lower ratings (better usability) than conventionally trained subjects, and that both groups reported higher ratings in the delayed trial, although the run difference was not significant. The interaction plot for Shut Down (figure 5.4, page 37) shows that criteria-trained subjects reported better usability than those in the conventionally-trained population. Here, however, both groups reported better usability ratings in the delayed trial. It is unclear why the data is contrary to expectations. It is possible that the relative simplicity of the shut down task or the similarity between certain elements of the home and shut down tasks made subjects feel more comfortable in their execution and led to better ratings in the second trial.

When subjects evaluated the interface over the span of all tasks, the results were highly significant in favor of criteria-trained subjects. Overall, the results suggest that ease of error recovery may be one of the most significant issues for users, and the one most likely to benefit from a change in training method or focus.

Control and label clarity was another issue highlighted by the All Tasks evaluation. Although subjects in both training method groups reported problems with their understanding of controls and labels, those trained to criteria reported better usability ratings than their counterparts.

Conventionally trained subjects did not report significantly greater difficulty than subjects trained to criteria when completing some of the less complex tasks, even Call Program, which comprises a major portion of the First Part task. Possibly, the increase in task complexity caused by adding the extra elements to Call Program results in a task sequence too long to reliably complete without significant practice or prompting from the interface. In fact, interviews with subjects confirmed that they found it difficult to recall the next step because the interface did not provide prompts.

Difficulty in understanding the menu structure unquestionably contributed to subject confusion while performing First Part, but was not an issue when performing simpler tasks. Interestingly, subjects did not report this as a problem when considering the usability of the interface as a whole. Again, the troubles were reported in the most complex task sequence,

suggesting that some form of prompting is necessary to assist operators in performing the step-by-step sequence of elements.

The usability study conducted by Rogerson (1998) indicated that usability problems were likely to stem from the difficulty of finding the correct controls on the interface panel, and understanding the associated labeling. Examination of the experimental session video tapes and feedback from subjects in this study seem to confirm those conclusions: subjects spent considerable time searching for the proper controls. Conventionally trained subjects reported more difficulty than those trained to criteria in doing this.

Error correction was clearly seen as a significant problem by subjects. Here too, the most complex task returned the strongest criticism. Overall impressions of ease of recovery were negative as well. During the sessions, subjects who entered error conditions were observed to stop, often for long periods of time, and try several remedial actions before finding the proper corrective action or asking for assistance. Subjects trained to criteria reported significantly less difficulty than those trained conventionally.

When asked about overall impressions of ease of interface operation, significant differences were detected only in the first part task, where conventionally-trained subjects reported greater difficulty than criteria-trained subjects.

As a whole, the usability data indicates that criteria-trained subjects generally viewed the interface as more usable, while conventionally trained subjects reported greater difficulty in using the interface. It is reasonable to conclude that training to criteria could help to address some of the usability problems inherent in the interface examined.

The only significant effect due to training delivery was found in Home, where subjects trained in groups returned better total task time performance compared to those trained individually. Overall, the ANOVA output for delivery effects in time and usability data shows evenly mixed results (Table 5.1, page 31), indicating that training delivery made little if any difference in subject performance, a conclusion which is in agreement with the findings of Guetzkow et al (in Travers, 1977). This conclusion is especially interesting when one considers that, in contrast to the observations made in the training facility (see page 16), the author noted that group-trained subjects in the present study tended to pay close attention to the actions of their peers, and used idle time to rehearse.

When the total task time, usability, and count data results (Table 5.1, page 31) are examined as a whole, several striking patterns are apparent. In the method effects, the non-significant as well as the significant results show that the train-to-criteria method is superior to the conventional protocol, a pattern which is present in time, usability and query count data. Such consistency suggests that the method of training does indeed make a difference.

Run effects were also prevalent. In fact, run effects appear in task time, all but three of the usability measures, and in query count data. Examination of the tabulated data confirmed that retention was a problem common to all four of the subpopulations examined.

Overall, interactions were not prevalent in the results, nor did they appear to follow any patterns. As described above, only two statistically significant interactions were identified for metrics. A significant method-run interaction was also identified for the overall impression of the shut down task.

6.2 Overall Conclusions

The results of this study indicate that the train to criteria method would be an improvement over conventional methods of training, and that training to criteria does in fact help to overcome some of the usability problems inherent in the CNC controller studied.

Subjects trained to criteria displayed superior performance, particularly in complex tasks. They required less time to perform complex tasks and required less assistance from reference materials and the analyst. When trained to criteria, subjects reported significantly greater ease of operating the interface and performing the desired tasks. Subjects trained to criteria required from three to six trials, with a mean of 4.55 trials (SD=0.759) to achieve fluency in the operations. When a 95% confidence interval is generated around this mean, it can be seen that the number differs significantly from the three trials given to conventionally trained subjects. This suggests that the number of practice opportunities afforded by conventional training is not adequate to ensure that an average trainee reaches fluency.

Although it might be a tempting means of improving the training protocol, simply increasing the number of trials would not be a substitute for training to criteria, since it would not address the additional training needs of those trainees requiring more than the mean number of

trials. Only training to criteria can assure that individual differences in learning rates and styles are addressed.

Training operators to criteria would allow individual operators to better internalize the task sequences necessary to operate the machine, and potentially complete the training with a higher degree of fluency. Further, additional practice opportunities would help to compensate for differences in learning rates exhibited by different operators, and allow instructors to focus on those needing further instruction on particular facets of the training, or to change their approach for certain individuals. For instance, a different training approach may be warranted for holistic students who tend to prefer a global approach that provides exercise in the total skill, than is used for serial students who obtain more benefit from step-by-step instruction. Similarly, more practice may be necessary for trainees with weaker mathematical backgrounds, since knowledge of mathematics has been linked to motivation and success in learning programming and the use of computers. (Van der Veer, 1989).

It should be noted that neither the conventional nor the criteria training method addresses problems associated with run effects, a point which is illustrated by the prevalence of run effects in the data for both conventionally-trained and criteria-trained subjects. Because run effects result from knowledge decay, training cannot be expected to provide a full solution to this problem. Once a subject has completed the training, regardless of which method has been used, his or her command of the material will certainly begin to decay. Obviously, re-training would provide a means of improving operator performance in cases where the interface is used infrequently or in operations performed infrequently.

Although modification of training methods might provide a quick means of improving operator performance, changing the design of the interface to eliminate usability traps would undoubtedly have a major impact on the usability of the interface, which was addressed by Rogerson (1998).

The results of this study seem to confirm Rogerson's findings: subjects were observed encountering many of the same difficulties predicted by usability analysis and their comments during the experimental sessions echoed the findings of the previous study.

When examining the usability data, one can see that, regardless of training method, there are still usability problems inherent in the interface, and that they are negatively impacting the

user. Improvement of the interface's usability may provide the best avenue toward long-term improvement in an operator's ability to maintain fluency of operation.

6.3 Strengths and Weaknesses of the Study

The present study examined relatively short-term retention and performance in subjects with little or no machining experience. Although all of the subjects examined had some technical exposure in their backgrounds, whether through vocation, computer training, or an engineering curriculum, and had educational backgrounds including at least some college, the population studied does not mirror the population of users likely to be seen at the training facility.

Although measures were taken to make the subjects' experience as close as possible, within the constraints of facilities, subject availability, and resources, to the training experience received by the author, there were unavoidable differences. The training delivered by the analyst, for instance, undoubtedly differs from that provided by the instructors at the training facility. There is also a considerable difference between intensive interface training conducted in the space of an hour and a half with quickly repeated practice and exposure to tasks, and the four and a half days of intensive programming training with less frequent practice and exposure to interface operation. During the course of this experiment, subjects received no training in G- and M-Code programming and were given no exposure beyond the brief overview necessary to understand the function of the program within the context of interface operation and within the scope of the selected tasks. Trainees at the training facility receive extensive instruction in writing and manipulating machine programs. Whether or not these differences are problematic may be a matter for further study, but it should be emphasized that the purpose of the present study was comparing the training methods.

While the results provided only weak evidence of a group effect, one must question how much reinforcement is provided for the average trainee in the larger groups trained at the training facility. In the author's experience, a limited number of those trainees actually followed every move made by every one of the other trainees as they performed the target tasks. In the scope of this study, it is impossible to say whether the group effect is significant, and whether it differs from that present in the pairs trained during the experiment.

Naturally, any experimental population will exhibit modified behavior which may not be present in the broader population. Such behavioral changes may influence studies in ways that cannot be readily determined.

The design of this study attempted to minimize the inherent problems by examining specific behaviors within subjects. While there are certainly considerable differences between the experimental conditions and the reality of the training facility, the counterbalancing of the experiment ensured isolation of the effects of interest, namely differences between: training with three practices and training to criteria; solo training and training in pairs; and trial. It is reasonable to expect that the enhanced performance seen in subjects trained to criteria in the Brinkman lab experiment would also be seen in subjects trained to criteria in the training facility. Likewise, it would be reasonable to expect a group effect, although its exact nature is a matter for further study. A discussion of run effects beyond the simple decay of skill over time is not relevant to the actual training facility, since the decay profile cannot easily be determined.

6.4 Future Directions

Many areas of study remain open in the realm of CNC interface development. As mentioned above, there are various effects worthy of study in the context of CNC interfaces: group effects, the profile of knowledge decay over time, learning curve, and the interaction of programming training with interface operation training.

One cannot examine CNC interface usability without questioning the impact of advancing technology on their operation. For instance, does the use of engineering utilities such as MasterCam have an effect on an operator's ability to perform basic machine functions? Will implementation of such packages lead to further division between those who program machines and those who run them, in effect expanding the ranks of dedicated operators? Will advances in machine technology remove humans from the operational portions of the loop entirely?

CNC machine tools are of paramount importance to industry worldwide, but there is much to be done in improving their usability. The introduction of conversational controllers and Windows-based operating systems is only one avenue of approach. As long as human operators are required to operate CNC machines, improvements in usability are likely to expand the pool of operators, decrease training costs, and eliminate wasted time, effort, and materials.

Appendix A

ROCHESTER INSTITUTE OF TECHNOLOGY
DEPARTMENT OF INDUSTRIAL AND SYSTEMS ENGINEERING
81 Lomb Memorial Drive
Rochester, New York 14623

Phillip A. Rogerson, Principal Investigator **Subject Code:_____**
Dr. Jacqueline Mozrall, Advisor

Description of Experimental Tasks for CNC Interface Retention Study:

In this experiment, you will be introduced to the XXXX CNC machine controller and lead through two common operational tasks using the interface.

The training and experimental sessions will be videotaped to allow subsequent analysis of your interaction with the interface. The purpose of this experiment is not to evaluate your ability as a machinist, or your ability to learn, but to gather information about the ease of retaining knowledge you receive when learning to operate the interface.

You will first be led through the task by the experimenter in a hands-on instructional session. You may ask any questions necessary to understand the task being performed and the operation of the interface. Following the training session, you will be asked to perform the tasks on your own. You will receive general instructions and should carry them out to the best of your ability. If you need assistance or clarification while performing the experimental trial, you may refer to the task reference you will be given. If you perform incorrect or inappropriate actions, the experimenter may stop and assist you or take measures to correct your actions. The experimenter may also stop you to ask questions as you work to gain additional information about your understanding of the machine interface.

The tasks will consist of the following steps:

- Power Up and Zero Return (Home)
- Activate a Stored Program
- Opening/Closing Collet
- Make First Part
- Shutting Down Machine

I have read the description of the experimental procedure. Initial: ______ Date _____

Appendix B

ROCHESTER INSTITUTE OF TECHNOLOGY
DEPARTMENT OF INDUSTRIAL AND SYSTEMS ENGINEERING
81 Lomb Memorial Drive
Rochester, New York 14623

Phillip A. Rogerson, Principal Investigator
Dr. Jacqueline Mozrall, Advisor

Subject Code ________

Informed Consent Form

The objective of this experiment is to evaluate and understand knowledge retention characteristics of the XXXX CNC interface over time. Before signing this form, you must be provided with a written description of the experiment in which you are about to participate. The experiment includes training, practice and a two task sessions using the interface on a XXXXX CNC lathe. The sessions will be video taped for the purposes of assessing interface use proficiency by means of task times and number of error incidences. The first session will last approximately 2 hours and the second will last approximately 1 hour.

The operational portions of the lathe are enclosed in a substantial housing. The access door is provided with interlocks to prevent operation of the machine with the door open. Task steps requiring the operator to place his/her hands inside the machine housing will be performed by the investigator. You will therefore never be exposed to moving machine components. To eliminate the chance of sustaining cuts or abrasions due to contact with chips or sharp edges of machined parts, no parts will actually be machined.

To maximize awareness of machine safety, experimental you will be made aware of any potential for injury and operations you carry out will be directly monitored by the investigator, who will stop the experiment should any unsafe acts be performed.

With these measures taken, it is believed that there is no chance of physical injury to you.

If you decide to participate in the experiment, all of the data regarding your session will be kept strictly confidential. To ensure confidentiality, you will be identified with a numerical code. Only the investigator will have access to information linking you with the code. Session videotapes will be kept under lock and key for the duration of the study and will be viewed only by the investigator and his advisors. At the conclusion of the study, the videotapes will be destroyed. No unauthorized individuals will have access to any data and any material connecting you with specific data will be destroyed upon completion of the investigation.

I, ________________________________ have read the description of the experiment and agree to participate to the best of my ability in this study. I understand that my participation in this study is voluntary. If I participate, I do so of my own free will. I understand that I may withhold any information I do not wish to disclose, and that I do not have to answer any questions that I do not wish to answer. I also understand that I may leave at any time during the

experiment if I choose to do so, and the experimenter may terminate my involvement in this study if necessary.

For any further information regarding this experiment, please contact Phil Rogerson, CIMS room 2450, at 475-5807, or Dr. Jacqueline Mozrall, CIMS room 2404, at 475-7142.

Name ____

Signature______________________________________ Date ______________

Appendix C

ROCHESTER INSTITUTE OF TECHNOLOGY

DEPARTMENT OF INDUSTRIAL AND SYSTEMS ENGINEERING
81 Lomb Memorial Drive
Rochester, New York 14623

Phillip A. Rogerson, Principal Investigator
Dr. Jacqueline Mozrall, Advisor

Subject Code:_____

Demographic Survey Form

Please fill out the following information. You can be assured of complete confidentiality. Prior to the experiment you are assigned a subject code number, above right, which will be used on all data forms and videotapes so that you will remain anonymous. Only the experimenter will have access linking your personal data with your code number.

Age:_______

Schooling completed (check the highest that applies):

_____ High school _____Technical/Trade School _____ 2 Year Degree

_____ Some College _____ 4 Year Degree ______ Some Graduate Work

What is your current employment position?

Do you have any machining experience? _____ Yes _____ No

If Yes, please describe:

Do you have any experience with CNC machine tools? _____ Yes _____No

If Yes, please describe:

Have you ever used XXXXX CNC Machine Tools? _____ Yes _____No

If yes, Please describe the XXXXX CNC machines you have experience with:

Have you ever used a XXXX CNC machine controller? _____Yes _____No

If yes, please describe the XXXX CNC controller you used

Have you ever used a XXXX CNC controller? _____ Yes _____ No

How many hours did you sleep last night? ______

How many hours per night do you normally sleep? ______

Have you consumed alcoholic beverages in the last 24 hours? _____Yes _____No

If yes, please indicate how much and how long ago:

Do you have physical conditions that might adversely affect your ability to safely operate a CNC machine tool? _____Yes _____No

If yes, please describe:

Are you currently taking any medications or other substances that may affect your ability to operate machinery safely? _____Yes _____No

If yes, please describe:

Appendix D
Task Sequence for Machine Operator

1. Power Up and Zero Return (Home)
    - Turn *Main Disconnect Switch* ON
    - Turn *Main Air Valve* ON
    - Turn *Control ON/OFF Switch* to ON
    - Wait for control screen to come on
    - Pull *Emergency-Stop* button out and release
    - Verify *Coolant Guard Door* is closed
    - Set *Machine Modes Selector Switch* to JOG
    - Set *Axis Selector Switch* to E
    - Press the *right-hand Z/E push button* to move the tailstock to the reference position
    - Open and close the Guard Door to verify guard door switch and clear the verification alarm
2. Activate a Stored Program
    - Set the *Mode Selector Switch* to AUTOMATIC mode
    - Press *PROG* key
    - Key in O (letter O) and the desired program number
    - Press the *CURSOR* key
3. Opening/Closing Collet
    - Place stock in collet
    - Press Main OPEN/CLOSE button
    - Remove stock from collet
4. Make First Part
    - Press RESET key
    - Press PROGRAM key
    - Activate desired program
    - Set MODE SELECTOR switch to Single mode
    - Close guard door

- Press CHECK soft key
- Press OPTION STOP button
- Turn RAPID OVERRIDE feed switch to "Low"
- Turn FEEDRATE OVERRIDE switch to 10%
- Press CYCLE START button to execute each program block

5. Shutting Down Machine

- Check that *Cycle Start* is not active (push button light is off)
- Check that program is completed and machine is stationary
- Press *Emergency-Stop* button
- Turn *Control ON/OFF switch* to OFF
- Turn *Main Air Valve* OFF
- Turn *Main Disconnect Switch* to OFF

Appendix E

ROCHESTER INSTITUTE OF TECHNOLOGY

DEPARTMENT OF INDUSTRIAL AND SYSTEMS ENGINEERING
81 Lomb Memorial Drive, Rochester, New York 14623

Phillip A. Rogerson, Principal Investigator
Dr. Jacqueline Mozrall, Advisor

Subject Code_______

Subjective Assessment of Usability

Using the following scale, please rate the usability qualities of the machine interface.

Rating	Level of usability	Effort Required
1	Very Easy, highly desirable	Operator mental effort is minimal and desired performance is easily attainable
2	Easy, desirable	Operator mental effort is low and desired performance is attainable
3	Fair, mild difficulty	Acceptable operator mental effort is required to attain adequate system performance
4	Minor, but annoying difficulty	Moderately high operator mental effort is required to attain adequate system performance
5	Moderately objectionable difficulty	High operator mental effort is required to attain adequate system performance
6	Very objectionable, but tolerable difficulty	Maximum operator mental effort required to attain adequate system performance
7	Major difficulty	Maximum operator mental effort is required to bring errors under control
8	Major difficulty	Maximum operator mental effort is required to avoid large or numerous errors
9	Major Difficulty	Intense operator mental effort is required to accomplish task but frequent or numerous errors persist
10	Impossible	Instructed task cannot be accomplished reliably

	Usability Characteristic	Rating
1.	How would you rate the interface with respect to the ease of finding the correct switch, knob, or button and understanding the labeling?	
2.	How would you rate the interface with respect to ease of understanding menu structure?	
3.	How would you rate the interface with respect to the ease of understanding the screen displays and finding the correct soft key or data display?	
4.	If you made errors during the operation of the interface, how would you rate the ease of making corrections or recovering from the error?	
5.	How would you rate the usability of the interface with respect to the ease of using multi-function keys?	
6.	Overall, how would you rate the usability of the interface with respect to ease of operation?	

Appendix F: Objective Data Analysis Output

Tabulation and Boxplot Results

Task 1. Power up and Zero Return
Response variable: Time

Tabulated Statistics: Method, Delivery, Trial

Control: Trial = 1
Rows: Method
Columns: Delivery

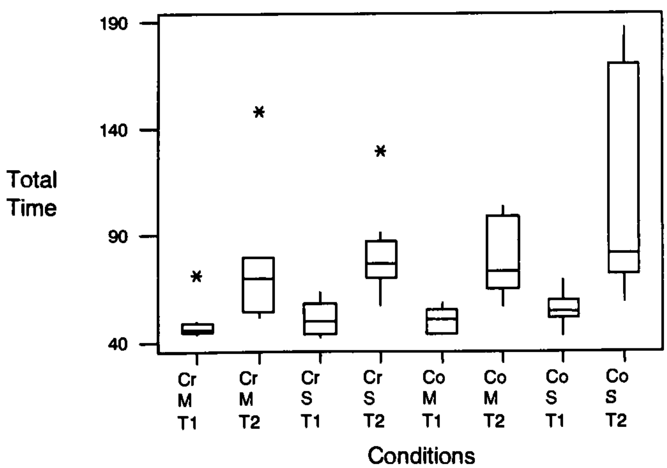
	M	S	All
Cr	48.736	50.785	49.760
	49.880	63.590	--
	71.360	42.660	
	47.200	57.410	
	45.500	48.180	
	43.660	49.310	
	48.580	50.810	
	45.740	42.220	
	43.740	49.920	
	47.210	43.980	
	44.490	59.770	
Co	50.187	55.196	52.692
	52.820	68.250	--
	43.590	42.910	
	58.130	59.090	
	48.480	56.860	
	43.510	51.160	
	49.900	52.520	
	55.430	51.380	
	54.610	50.450	
	51.700	62.340	
	43.700	57.000	
All	49.462	52.991	51.226
	--	--	--

Control Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	74.370	80.950	77.660
	76.300	73.130	--
	55.710	57.280	
	79.680	90.850	
	51.410	67.720	
	69.990	129.130	
	79.860	80.950	
	70.400	76.540	
	51.490	77.500	
	60.670	70.470	
	148.190	85.930	
Co	78.090	107.450	92.770
	102.730	74.270	--
	75.860	187.110	
	65.240	58.630	
	64.840	74.020	
	56.380	102.270	
	98.690	183.170	
	65.640	165.000	
	83.220	70.200	
	98.690	87.820	
	69.610	72.010	
All	76.230	94.200	85.215
	--	--	--

Boxplot of operation time vs. training method, training delivery, and trial

(Cr=criteria, Co=conventional, M=multiple, S=single, T1=trial 1, T2=trial 2)



Task 1. Power up and Zero Return
Response variable: Queries

Tabulated Statistics: Method, Delivery, Trial

Control: Trial = 1
Rows: Method
Columns: Delivery

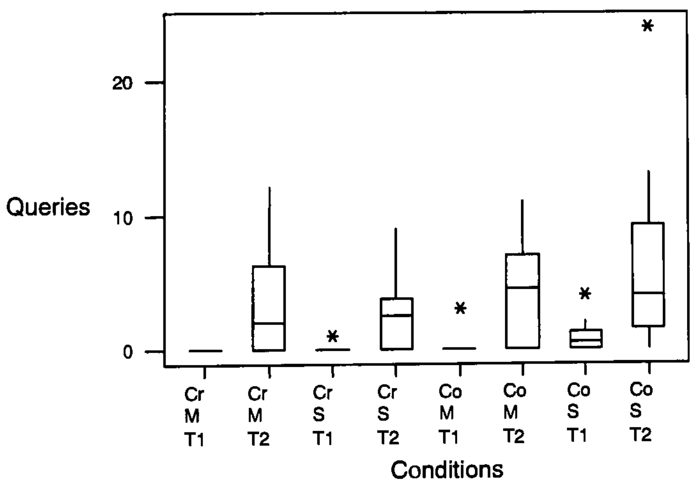
	M	S	All
Cr	0.0000	0.1000	0.0500
	0.0000	0.0000	--
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	1.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
Co	0.3000	0.9000	0.6000
	0.0000	0.0000	--
	0.0000	1.0000	
	0.0000	0.0000	
	0.0000	1.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	3.0000	1.0000	
	0.0000	4.0000	
	0.0000	2.0000	
All	0.1500	0.5000	0.3250
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	3.3000	2.7000	3.0000
	7.0000	3.0000	--
	1.0000	0.0000	
	3.0000	6.0000	
	0.0000	9.0000	
	3.0000	3.0000	
	12.0000	0.0000	
	0.0000	3.0000	
	0.0000	0.0000	
	1.0000	2.0000	
	6.0000	1.0000	
Co	4.0000	6.4000	5.2000
	4.0000	0.0000	--
	0.0000	13.0000	
	0.0000	0.0000	
	1.0000	6.0000	
	0.0000	3.0000	
	7.0000	24.0000	
	11.0000	8.0000	
	7.0000	3.0000	
	5.0000	2.0000	
	5.0000	5.0000	
All	3.6500	4.5500	4.1000
	--	--	--

Boxplot of queries vs. training method, training delivery, and trial

(Cr=criteria, Co=conventional, M=multiple, S=single, T1=trial 1, T2=trial 2)



Task 1. Power up and Zero Return
Response variable: Total Errors

Tabulated Statistics: Total Errors vs. Method, Delivery, Trial:

Control: Trial = 1
Rows: Method
Columns: Delivery

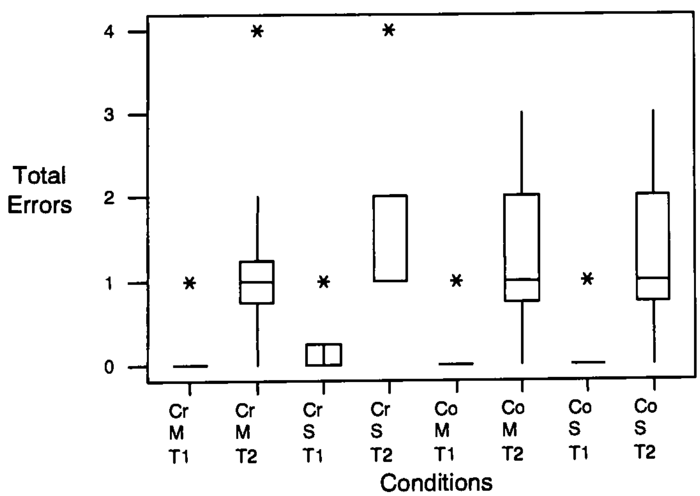
	M	S	All
Cr	0.1000	0.2000	0.1500
	0.0000	0.0000	--
	1.0000	1.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	1.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
Co	0.1000	0.1000	0.1000
	0.0000	1.0000	--
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	1.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
All	0.1000	0.1500	0.1250

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	1.2000	1.5000	1.3500
	1.0000	1.0000	--
	1.0000	1.0000	
	1.0000	2.0000	
	0.0000	2.0000	
	1.0000	1.0000	
	1.0000	1.0000	
	2.0000	4.0000	
	0.0000	1.0000	
	1.0000	1.0000	
	4.0000	1.0000	
Co	1.2000	1.2000	1.2000
	2.0000	1.0000	--
	1.0000	3.0000	
	1.0000	1.0000	
	1.0000	1.0000	
	1.0000	1.0000	
	2.0000	1.0000	
	0.0000	2.0000	
	1.0000	0.0000	
	3.0000	2.0000	
	0.0000	0.0000	
All	1.2000	1.3500	1.2750

Boxplot of Total Errors vs. training method, training delivery, and trial

(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 1. Power up and Zero Return

Response Variable: Undetected Errors

Tabulated Statistics: Undetected Errors vs. Method, Delivery, Trial

Control: Trial = 1
Rows: Method
Columns: Delivery

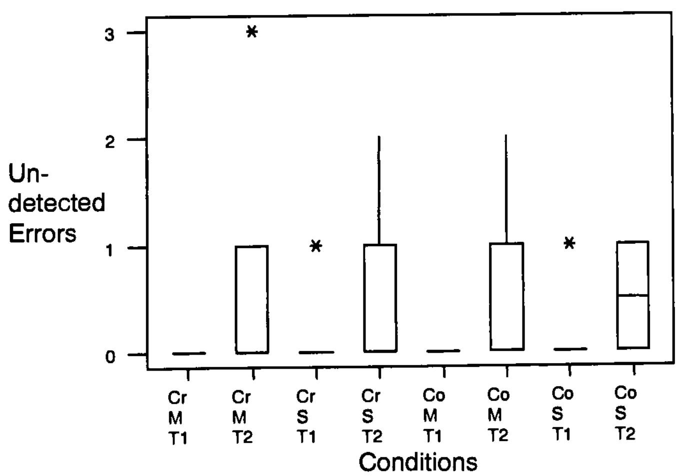
	M	S	All
Cr	0.00000	0.10000	0.05000
	0.00000	0.00000	--
	0.00000	1.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
Co	0.00000	0.10000	0.05000
	0.00000	1.00000	--
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
All	0.00000	0.10000	0.05000
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	0.60000	0.50000	0.55000
	1.00000	1.00000	--
	1.00000	0.00000	
	0.00000	0.00000	
	0.00000	1.00000	
	0.00000	0.00000	
	0.00000	1.00000	
	1.00000	2.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	3.00000	0.00000	
Co	0.70000	0.50000	0.60000
	0.00000	1.00000	--
	0.00000	1.00000	
	1.00000	1.00000	
	1.00000	1.00000	
	1.00000	0.00000	
	2.00000	0.00000	
	0.00000	0.00000	
	1.00000	0.00000	
	1.00000	1.00000	
	0.00000	0.00000	
All	0.65000	0.50000	0.57500
	--	--	--

Boxplot of Undetected Errors vs. training method, training delivery, and trial

(Cr=criteria, Co=Conventional, M=multiple, S=single, T1=trial 1, T2=trial 2)



Task 2. Activate Stored Program

Response variable: Time

Tabulated Statistics: Time vs. Method, Delivery, Trial

Control: Trial = 1
Rows: Method
Columns: Delivery

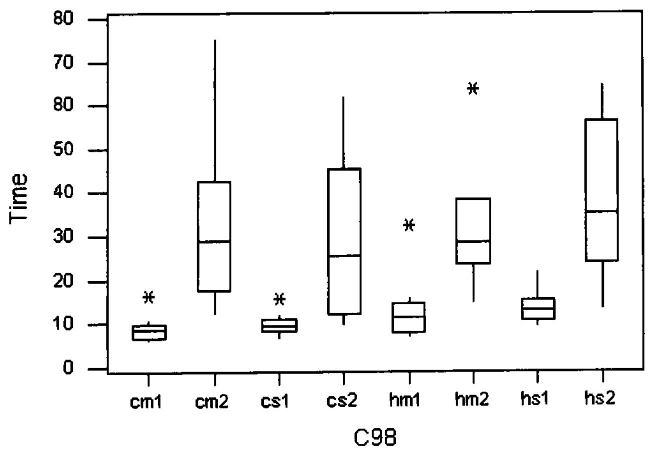
	M	S	All
Cr	8.804	9.868	9.336
	6.710	8.770	--
	8.560	9.810	
	6.600	11.900	
	8.280	9.880	
	6.340	9.200	
	10.600	10.510	
	6.220	7.220	
	16.260	9.130	
	9.600	6.800	
	8.870	15.460	
Co	12.827	13.437	13.132
	15.710	21.590	--
	7.240	14.190	
	13.110	13.950	
	7.820	12.470	
	8.260	10.450	
	12.530	10.190	
	10.120	9.450	
	32.530	10.830	
	13.820	13.570	
	7.130	17.680	
All	10.816	11.653	11.234
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	32.292	28.544	30.418
	43.410	12.280	--
	18.180	9.560	
	16.130	20.920	
	38.380	48.980	
	74.890	43.950	
	19.700	31.450	
	41.990	29.700	
	19.040	11.560	
	38.870	15.490	
	12.330	61.550	
Co	31.649	37.569	34.609
	63.540	59.020	--
	14.960	27.600	
	38.020	13.120	
	30.050	40.240	
	26.690	64.490	
	38.240	40.830	
	23.550	29.730	
	32.840	55.190	
	25.600	24.520	
	23.000	20.950	
All	31.971	33.057	32.514
	--	--	--

Task 2. Activate Stored Program

Boxplot of Time vs. Method, Delivery, Trial:
(Cr=criteria, H=conventional, m=multiple, s=single, 1=trial 1, 2=trial 2)



Task 2. Activate Stored Program

Response variable: Queries

Tabulated Statistics: Queries vs. Method, Delivery, Trial

Control: Trial = 1
Rows: Method
Columns: Delivery

	M	S	All
Cr	0.0000	0.0000	0.0000
	0.0000	0.0000	--
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
Co	0.2000	0.6000	0.4000
	0.0000	0.0000	--
	0.0000	2.0000	
	0.0000	0.0000	
	0.0000	2.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	1.0000	0.0000	
	1.0000	0.0000	
	0.0000	0.0000	
	0.0000	2.0000	
All	0.1000	0.3000	0.2000
	--	--	--

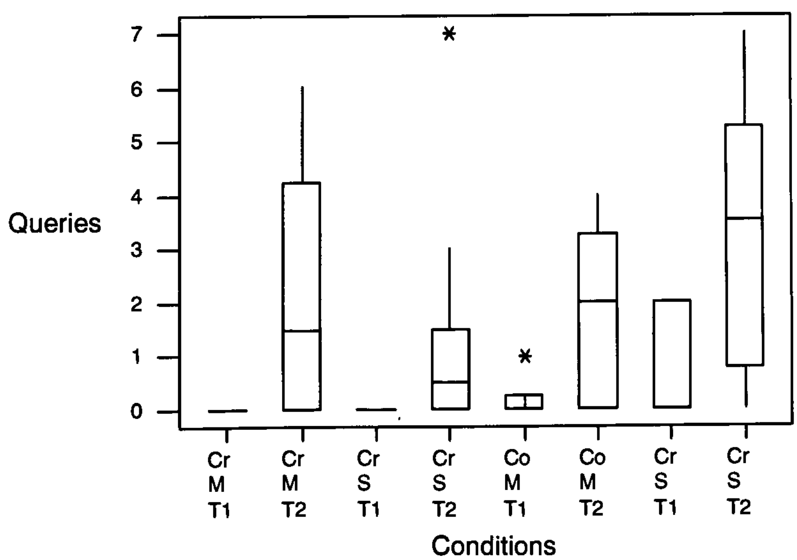
Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	2.2000	1.3000	1.7500
	5.0000	1.0000	--
	3.0000	0.0000	
	1.0000	1.0000	
	0.0000	7.0000	
	4.0000	0.0000	
	6.0000	0.0000	
	2.0000	1.0000	
	0.0000	0.0000	
	1.0000	0.0000	
	0.0000	3.0000	
Co	1.9000	3.4000	2.6500
	1.0000	7.0000	--
	0.0000	3.0000	
	0.0000	0.0000	
	0.0000	6.0000	
	3.0000	4.0000	
	3.0000	5.0000	
	4.0000	1.0000	
	4.0000	3.0000	
	1.0000	0.0000	
	3.0000	5.0000	
All	2.0500	2.3500	2.2000
	--	--	--

Task 2. Activate Stored Program

Boxplot of Queries vs. Method, Delivery, Trial:

(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 2. Activate Stored Program

Response variable: Total Errors

Tabulated Statistics: Total Errors vs. Method, Delivery, Trial

Control: Trial = 1
Rows: Method
Columns: Delivery

	M	S	All
Cr	0.3000	0.2000	0.2500
	0.0000	0.0000	--
	1.0000	1.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	2.0000	0.0000	
	0.0000	1.0000	
	0.0000	0.0000	
Co	0.3000	0.2000	0.2500
	0.0000	0.0000	--
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	1.0000	2.0000	
	0.0000	0.0000	
	1.0000	0.0000	
	1.0000	0.0000	
	0.0000	0.0000	
All	0.3000	0.2000	0.2500
	--	--	--

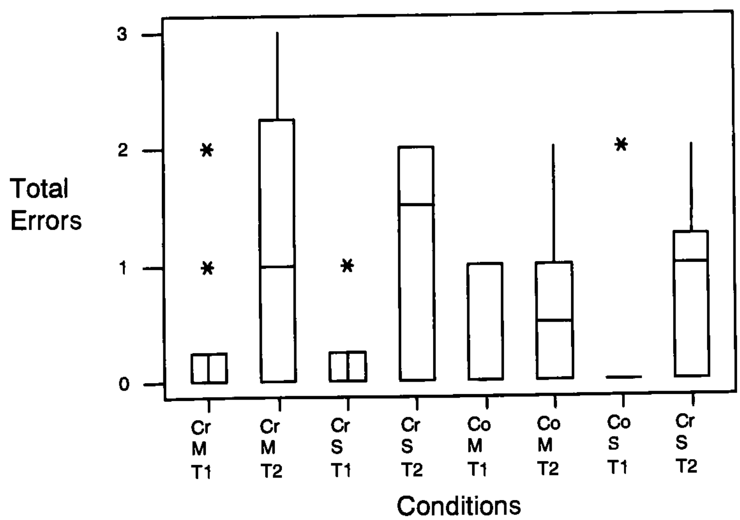
Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	1.2000	1.2000	1.2000
	1.0000	2.0000	--
	0.0000	2.0000	
	0.0000	0.0000	
	1.0000	1.0000	
	3.0000	2.0000	
	0.0000	0.0000	
	2.0000	1.0000	
	2.0000	0.0000	
	3.0000	2.0000	
	0.0000	2.0000	
Co	0.6000	0.8000	0.7000
	2.0000	2.0000	--
	0.0000	0.0000	
	1.0000	0.0000	
	1.0000	0.0000	
	0.0000	2.0000	
	0.0000	1.0000	
	1.0000	1.0000	
	0.0000	1.0000	
	1.0000	1.0000	
	0.0000	0.0000	
All	0.9000	1.0000	0.9500
	--	--	--

Task 2. Activate Stored Program

Boxplot of Total Errors vs. Method, Delivery, Trial:

(Cr=criteria, Co=conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 2. Activate Stored Program

Response variable: Undetected Errors

Tabulated Statistics: Undetected Errors vs. Method, Delivery, Trial

Control: Trial = 1
Rows: Method
Columns: Delivery

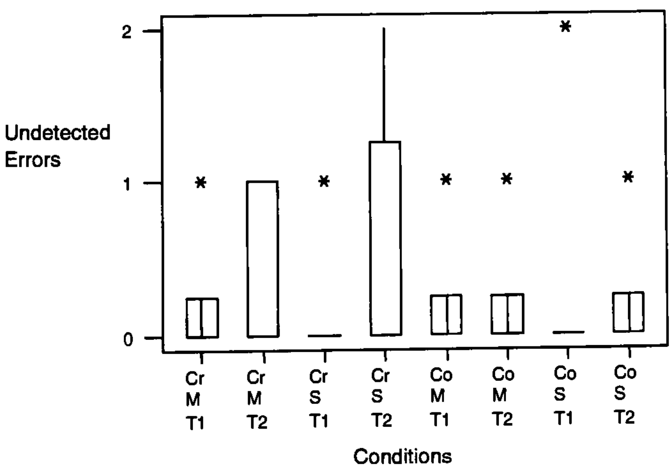
	M	S	All
Cr	0.20000	0.10000	0.15000
	0.00000	0.00000	--
	1.00000	1.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	1.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
Co	0.20000	0.20000	0.20000
	0.00000	0.00000	--
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	1.00000	2.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	1.00000	0.00000	
	0.00000	0.00000	
All	0.20000	0.15000	0.17500
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	0.30000	0.60000	0.45000
	0.00000	2.00000	--
	0.00000	2.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	1.00000	
	0.00000	0.00000	
	1.00000	0.00000	
	1.00000	0.00000	
	1.00000	0.00000	
	0.00000	1.00000	
Co	0.20000	0.20000	0.20000
	0.00000	0.00000	--
	0.00000	0.00000	
	1.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	1.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	1.00000	1.00000	
	0.00000	0.00000	
All	0.25000	0.40000	0.32500
	--	--	--

Task 2. Activate Stored Program

Boxplot of Undetected Errors vs. Method, Delivery, Trial:
(Cr=criteria, Co=conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 3. Collet Open/Close
Response variable: Time

Tabulated Statistics: Time vs. Method, Delivery, Trial

Control: Trial = 1
Rows: Method
Columns: Delivery

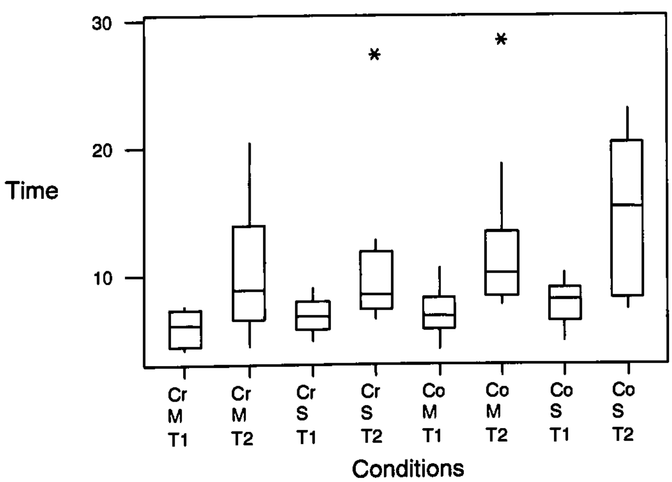
	M	S	All
Cr	6.020	6.841	6.431
	5.660	7.820	--
	7.160	5.810	
	6.600	7.370	
	4.410	8.270	
	5.490	5.350	
	4.440	6.980	
	4.160	4.820	
	7.550	6.460	
	7.070	6.520	
	7.660	9.010	
Co	7.001	7.796	7.399
	8.780	8.790	--
	4.130	5.980	
	10.480	7.980	
	7.820	10.150	
	7.060	8.240	
	8.000	4.800	
	6.490	8.990	
	5.660	8.950	
	5.900	7.560	
	5.690	6.520	
All	6.511	7.318	6.914
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	10.377	10.640	10.509
	18.550	8.410	--
	10.330	7.810	
	9.580	9.380	
	6.950	27.300	
	12.350	6.910	
	4.440	12.700	
	5.460	6.510	
	7.660	8.400	
	20.450	7.490	
	8.000	11.490	
Co	12.243	14.532	13.387
	10.420	10.990	--
	9.790	8.110	
	8.520	8.200	
	10.760	20.010	
	18.730	7.330	
	8.080	15.280	
	28.420	23.020	
	8.370	15.450	
	7.660	21.450	
	11.680	15.480	
All	11.310	12.586	11.948
	--	--	--

Boxplot of Time vs. Method, Delivery, Trial:

(Cr=criteria, Co=conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 3. Collet Open/Close
Response variable: Queries

Tabulated Statistics: Queries vs. Method, Delivery, Trial

Control: Trial = 1
Rows: Method
Columns: Delivery

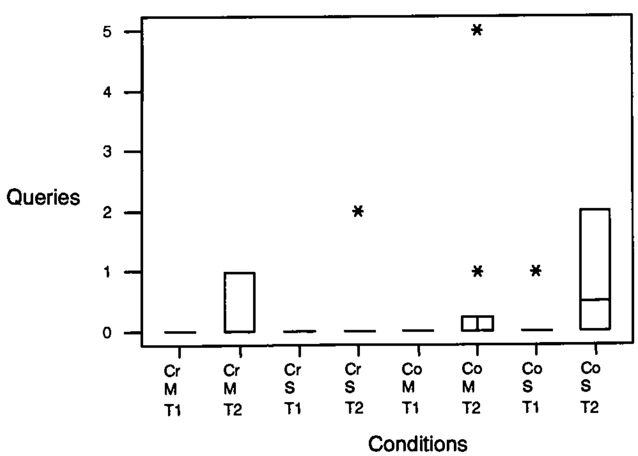
	M	S	All
Cr	0.0000	0.0000	0.0000
	0.0000	0.0000	--
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
Co	0.0000	0.1000	0.0500
	0.0000	0.0000	--
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	1.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
All	0.0000	0.0500	0.0250
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	0.4000	0.2000	0.3000
	1.0000	0.0000	--
	1.0000	0.0000	
	0.0000	0.0000	
	0.0000	2.0000	
	1.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	1.0000	0.0000	
	0.0000	0.0000	
Co	0.6000	0.8000	0.7000
	0.0000	0.0000	--
	0.0000	1.0000	
	0.0000	0.0000	
	0.0000	2.0000	
	1.0000	0.0000	
	0.0000	0.0000	
	5.0000	2.0000	
	0.0000	1.0000	
	0.0000	0.0000	
	0.0000	2.0000	
All	0.5000	0.5000	0.5000
	--	--	--

Boxplot of Queries vs. Method, Delivery, Trial:

(Cr=criteria, Co=conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 3. Collet Open/Close

Response variable: Total Errors

Tabulated Statistics: Recovery Time vs. Method, Delivery, Trial

Control: Trial = 1
Rows: Method
Columns: Delivery

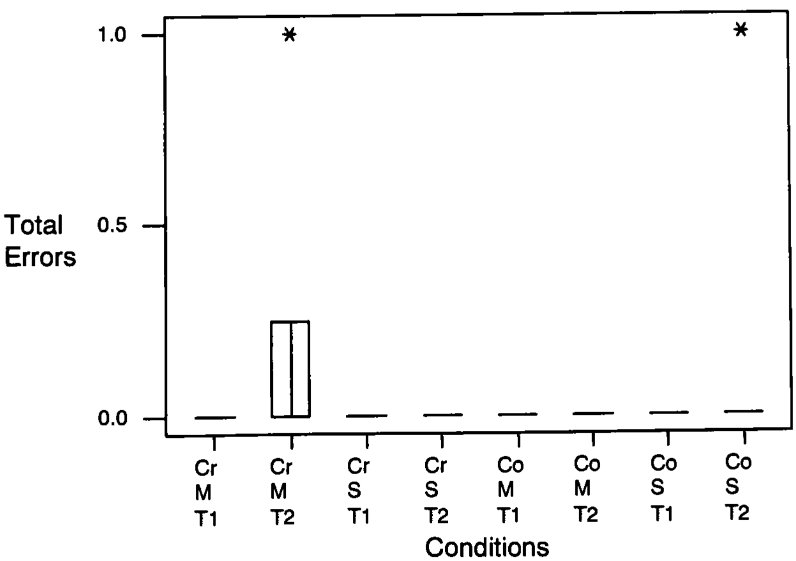
	M	S	All
Cr	0.00000	0.00000	0.00000
	0.00000	0.00000	--
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
Co	0.00000	0.00000	0.00000
	0.00000	0.00000	--
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
All	0.00000	0.00000	0.00000
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	0.20000	0.00000	0.10000
	1.00000	0.00000	--
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	1.00000	0.00000	
	0.00000	0.00000	
Co	0.00000	0.10000	0.05000
	0.00000	1.00000	--
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
All	0.10000	0.05000	0.07500
	--	--	--

Boxplot of Total Errors vs. Method, Delivery, Trial:

(Cr=criteria, Co=conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 4. Make First Part
Response variable: Time

Tabulated Statistics Time vs. Method, Delivery, Trial

Control: Trial = 1
Rows: Method
Columns: Delivery

	M	S	All
Cr	24.539	29.222	26.880
	29.670	31.520	--
	29.650	26.020	
	21.850	38.450	
	22.840	25.770	
	19.510	33.850	
	27.660	30.270	
	20.090	21.170	
	23.600	24.540	
	23.360	18.360	
	27.160	42.270	
Co	34.471	44.164	39.317
	59.400	82.910	--
	18.010	43.790	
	29.060	29.060	
	40.270	39.150	
	23.000	41.730	
	69.870	42.890	
	28.040	35.620	
	29.980	31.280	
	21.810	34.810	
	25.270	60.400	
All	29.505	36.693	33.099
	--	--	--

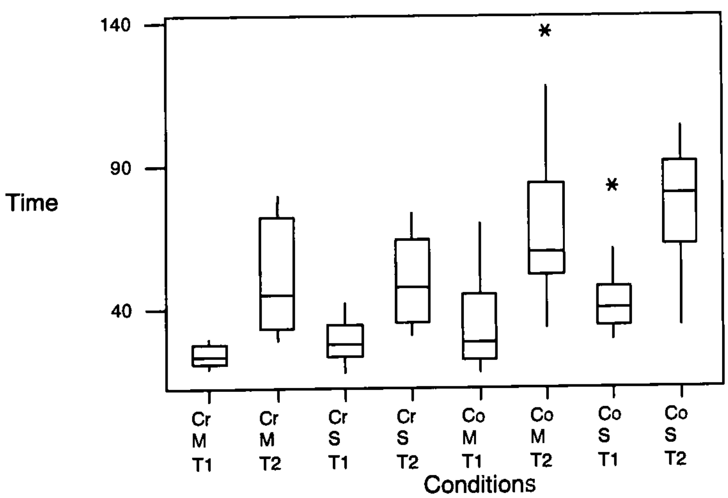
Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	51.063	49.450	50.256
	76.950	62.700	--
	51.490	35.170	
	44.700	35.360	
	29.410	73.790	
	79.500	39.490	
	45.550	51.820	
	33.890	50.550	
	33.590	44.590	
	44.710	31.010	
	70.840	70.020	
Co	70.663	76.568	73.616
	118.200	68.100	--
	44.740	81.050	
	72.810	34.340	
	62.650	62.820	
	54.180	95.920	
	70.280	104.000	
	33.400	61.190	
	137.200	90.030	
	57.650	79.360	
	55.520	88.870	
All	60.863	63.009	61.936
	--	--	--

Task 4. Make First Part

Boxplot of Time vs. Method, Delivery, Trial:

(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 4. Make First Part

Response variable: Queries

Tabulated Statistics: Queries vs. Method, Delivery, Trial

Control: Trial = 1
Rows: Method
Columns: Delivery

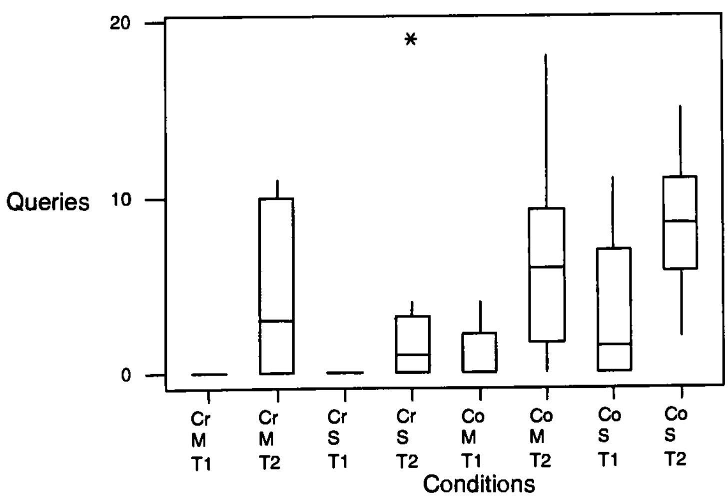
	M	S	All
Cr	0.0000	0.0000	0.0000
	0.0000	0.0000	--
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
Co	1.0000	3.1000	2.0500
	0.0000	2.0000	--
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	11.0000	
	0.0000	0.0000	
	2.0000	7.0000	
	3.0000	1.0000	
	4.0000	0.0000	
	0.0000	3.0000	
	1.0000	7.0000	
All	0.5000	1.5500	1.0250
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	4.2000	3.0000	3.6000
	11.0000	3.0000	--
	10.0000	2.0000	
	2.0000	4.0000	
	0.0000	19.0000	
	5.0000	0.0000	
	10.0000	0.0000	
	0.0000	0.0000	
	0.0000	1.0000	
	0.0000	0.0000	
	4.0000	1.0000	
Co	6.3000	8.4000	7.3500
	5.0000	11.0000	--
	0.0000	7.0000	
	1.0000	2.0000	
	2.0000	5.0000	
	4.0000	8.0000	
	7.0000	15.0000	
	9.0000	6.0000	
	18.0000	11.0000	
	7.0000	9.0000	
	10.0000	10.0000	
All	5.2500	5.7000	5.4750
	--	--	--

Boxplot of Queries vs. Method, Delivery, Trial:

(Cr=criteria, Co=conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 4. Make First Part

Response variable: Total Errors

Tabulated Statistics: Total Errors vs. Method, Delivery, Trial

Control: Trial = 1
Rows: Method
Columns: Delivery

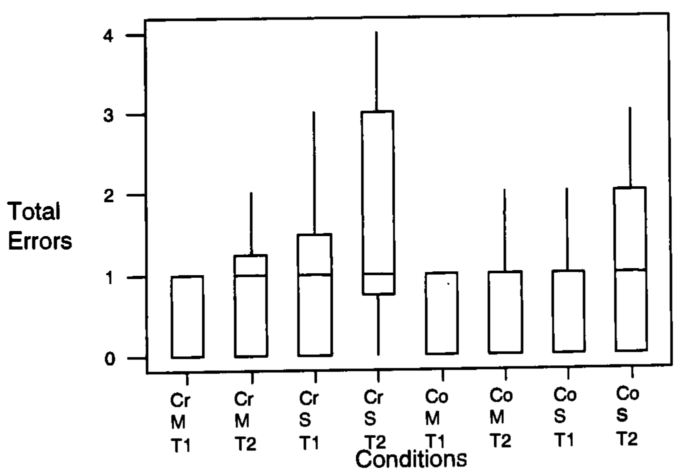
	M	S	All
Cr	0.4000	1.0000	0.7000
	1.0000	0.0000	--
	0.0000	3.0000	
	0.0000	1.0000	
	0.0000	0.0000	
	0.0000	1.0000	
	1.0000	0.0000	
	0.0000	0.0000	
	1.0000	3.0000	
	1.0000	1.0000	
	0.0000	1.0000	
Co	0.4000	0.8000	0.6000
	0.0000	1.0000	--
	1.0000	2.0000	
	0.0000	1.0000	
	1.0000	0.0000	
	0.0000	1.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	1.0000	
	1.0000	1.0000	
	1.0000	1.0000	
All	0.4000	0.9000	0.6500
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	0.9000	1.6000	1.2500
	1.0000	3.0000	--
	0.0000	2.0000	
	1.0000	1.0000	
	1.0000	1.0000	
	1.0000	0.0000	
	1.0000	0.0000	
	2.0000	1.0000	
	0.0000	4.0000	
	0.0000	3.0000	
	2.0000	1.0000	
Co	0.8000	1.0000	0.9000
	1.0000	0.0000	--
	1.0000	3.0000	
	1.0000	2.0000	
	2.0000	0.0000	
	1.0000	1.0000	
	1.0000	0.0000	
	0.0000	0.0000	
	1.0000	1.0000	
	0.0000	1.0000	
	0.0000	2.0000	
All	0.8500	1.3000	1.0750
	--	--	--

Boxplot of Total Errors vs. Method, Delivery, Trial:

(Cr=criteria, Co=conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 4. Make First Part

Response variable: Undetected Errors

Tabulated Statistics: Undetected Errors vs. Method, Delivery, Trial

Control: Trial = 1
Rows: Method
Columns: Delivery

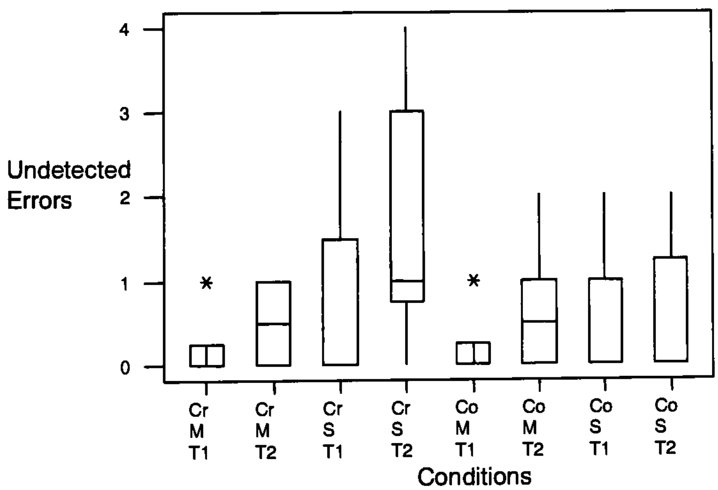
	M	S	All
Cr	0.2000	0.8000	0.5000
	0.0000	0.0000	--
	0.0000	3.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	1.0000	3.0000	
	1.0000	1.0000	
	0.0000	1.0000	
Co	0.2000	0.7000	0.4500
	0.0000	0.0000	--
	0.0000	2.0000	
	0.0000	1.0000	
	0.0000	0.0000	
	0.0000	1.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	1.0000	
	1.0000	1.0000	
	1.0000	1.0000	
All	0.2000	0.7500	0.4750
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	0.5000	1.6000	1.0500
	0.0000	3.0000	--
	0.0000	2.0000	
	1.0000	1.0000	
	1.0000	1.0000	
	1.0000	0.0000	
	0.0000	0.0000	
	1.0000	1.0000	
	0.0000	4.0000	
	0.0000	3.0000	
	1.0000	1.0000	
Co	0.6000	0.6000	0.6000
	1.0000	0.0000	--
	0.0000	2.0000	
	1.0000	2.0000	
	2.0000	0.0000	
	1.0000	1.0000	
	1.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	1.0000	
All	0.5500	1.1000	0.8250
	--	--	--

Boxplot of Undetected Errors vs. Method, Delivery, Trial:

(Cr=criteria, Co=conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 5. Power Down
Response variable: Time

Tabulated Statistics: Time vs. Method, Delivery, Trial

Control: Trial = 1
Rows: Method
Columns: Delivery

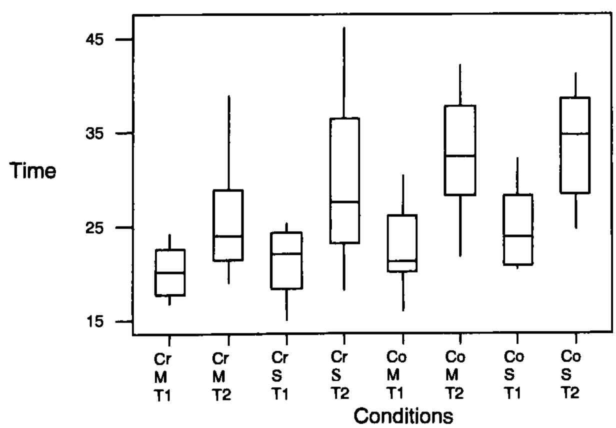
	M	S	All
Cr	20.313	21.420	20.866
	21.010	25.340	--
	22.090	18.360	
	17.840	24.200	
	16.770	24.360	
	19.320	19.610	
	23.850	24.670	
	20.670	14.970	
	19.780	20.800	
	17.560	18.360	
	24.240	23.530	
Co	22.440	24.748	23.594
	26.000	28.930	--
	16.040	25.750	
	21.210	20.570	
	20.530	32.150	
	20.230	22.880	
	30.280	20.450	
	26.240	24.930	
	22.540	22.800	
	20.070	28.030	
	21.260	20.990	
All	21.377	23.084	22.230
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	25.691	30.131	27.911
	21.930	28.490	--
	24.090	18.230	
	23.250	34.060	
	19.050	46.170	
	32.650	26.820	
	27.570	43.460	
	25.840	21.370	
	23.940	25.270	
	19.780	23.950	
	38.810	33.490	
Co	32.536	33.398	32.967
	26.910	29.990	--
	28.590	37.090	
	30.630	25.060	
	21.820	29.540	
	42.110	24.630	
	38.120	35.720	
	33.360	41.110	
	37.630	38.840	
	31.640	38.450	
	34.550	33.550	
All	29.113	31.764	30.439
	--	--	--

Boxplot of Time vs. Method, Delivery, Trial:

(Cr=criteria, Co=conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 5. Power Down
Response variable: Queries

Tabulated Statistics: Queries vs. Method, Delivery, Trial

Control: Trial = 1
Rows: Method
Columns: Delivery

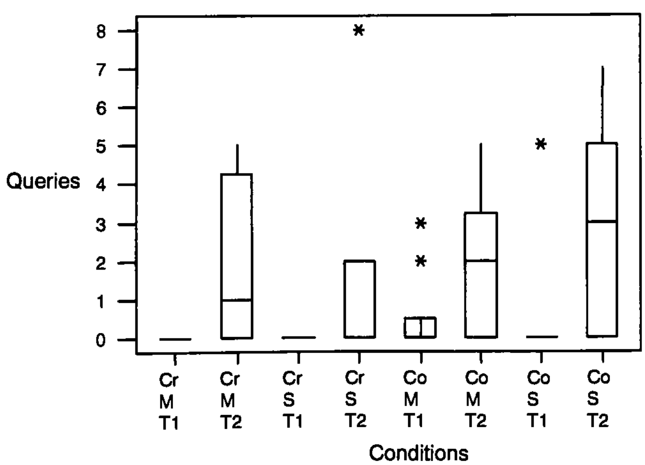
	M	S	All
Cr	0.0000	0.0000	0.0000
	0.0000	0.0000	--
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
Co	0.5000	0.5000	0.5000
	0.0000	0.0000	--
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	5.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	3.0000	0.0000	
	2.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
All	0.2500	0.2500	0.2500
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	1.8000	1.3333	1.5789
	5.0000	2.0000	--
	4.0000	0.0000	
	0.0000	2.0000	
	0.0000	8.0000	
	2.0000	0.0000	
	5.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	0.0000	0.0000	
	2.0000		
Co	1.8000	2.8889	2.3158
	0.0000	3.0000	--
	0.0000	4.0000	
	0.0000	0.0000	
	0.0000	5.0000	
	2.0000	0.0000	
	3.0000	2.0000	
	4.0000	7.0000	
	5.0000	0.0000	
	2.0000	5.0000	
	2.0000		
All	1.8000	2.1111	1.9474
	--	--	--

Boxplot of Queries vs. Method, Delivery, Trial:

(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 5. Power Down
Response variable: Total Errors

Tabulated Statistics: Total Errors vs. Method, Delivery, Trial

Control: Trial = 1
Rows: Method
Columns: Delivery

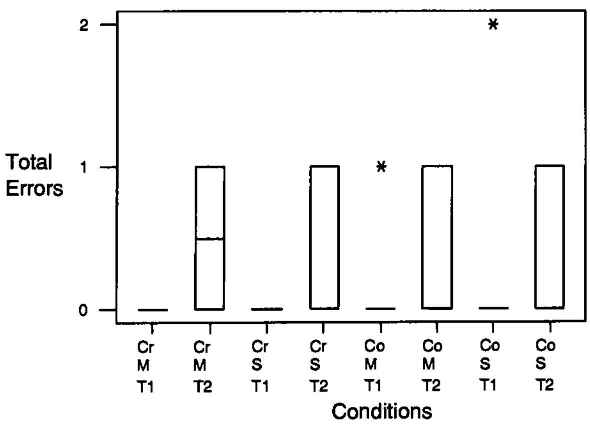
	M	S	All
Cr	0.00000	0.00000	0.00000
	0.00000	0.00000	--
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
Co	0.10000	0.20000	0.15000
	0.00000	0.00000	--
	0.00000	2.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	1.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
All	0.05000	0.10000	0.07500
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	0.50000	0.40000	0.45000
	1.00000	1.00000	--
	1.00000	0.00000	
	1.00000	0.00000	
	0.00000	0.00000	
	0.00000	1.00000	
	0.00000	0.00000	
	0.00000	1.00000	
	0.00000	1.00000	
	1.00000	0.00000	
	1.00000	0.00000	
Co	0.40000	0.30000	0.35000
	0.00000	0.00000	--
	0.00000	1.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	1.00000	1.00000	
	0.00000	0.00000	
	1.00000	0.00000	
	1.00000	1.00000	
	1.00000	0.00000	
All	0.45000	0.35000	0.40000
	--	--	--

Boxplot of Total Errors vs. Method, Delivery, Trial:

(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 5. Power Down
Response variable: Undetected Errors

Tabulated Statistics: Undetected Errors vs. Method, Delivery, Trial

Control: Trial = 1
Rows: Method
Columns: Delivery

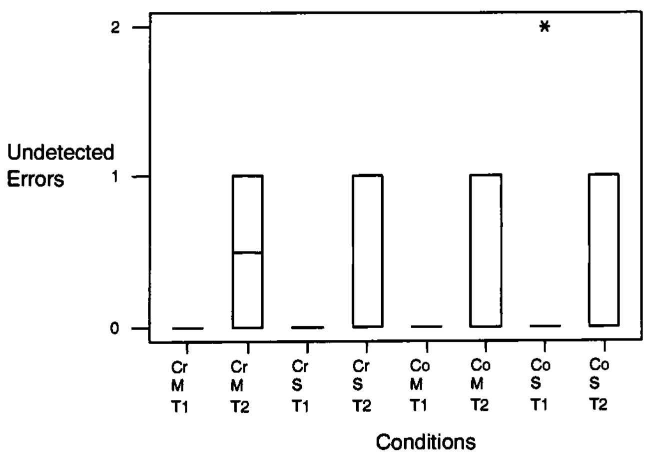
	M	S	All
Cr	0.00000	0.00000	0.00000
	0.00000	0.00000	--
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
Co	0.00000	0.20000	0.10000
	0.00000	0.00000	--
	0.00000	2.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
	0.00000	0.00000	
All	0.00000	0.10000	0.05000
	--	--	--

Control: Trial - 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	0.50000	0.30000	0.40000
	1.00000	1.00000	--
	1.00000	0.00000	
	1.00000	0.00000	
	0.00000	0.00000	
	0.00000	1.00000	
	0.00000	0.00000	
	0.00000	1.00000	
	0.00000	0.00000	
	1.00000	0.00000	
	1.00000	0.00000	
Co	0.30000	0.30000	0.30000
	0.00000	0.00000	--
	0.00000	1.00000	
	0.00000	0.00000	
	0.00000	1.00000	
	0.00000	0.00000	
	1.00000	0.00000	
	0.00000	0.00000	
	1.00000	0.00000	
	1.00000	1.00000	
	0.00000	0.00000	
All	0.40000	0.30000	0.35000
	--	--	--

Boxplot of Undetected Errors vs. Method, Delivery, Trial:

(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Appendix G: Objective Data Analysis Output
Chi Square Results

Chi-Square Test of Make First Part Data

The test for Queries returned the following results:

Queries

Observed

	Trial 1	Trial 2	Sums
Criteria	0	72	72
Conventional	41	147	188
Sums	41	219	260

Estimated Expected

	Trial 1	Trial 2	Sums
Criteria	11.35385	60.64615	72
Conventional	29.64615	158.3538	188
Sums	41	219	260

ChiSquare: **18.6418 >= 3.84**
Reject Ho at 5%. Dependence exists.

Chi Square Test of Power Up/Power Down Pooled Data

The test for Queries returned the following results:

Queries

Observed

	Trial 1	Trial 2	Sums
Criteria	1	90	91
Conventional	22	148	170
Sums	23	238	261

Estimated Expected

	Trial 1	Trial 2	Sums
Criteria	8.019157	82.98084	91
Conventional	14.98084	155.0192	170
Sums	23	238	261

ChiSquare: **10.34419 >= 3.84**
Reject Ho at 5%. Dependence exists.

Chi Square Test of All Tasks Pooled Data

The test for Queries returned the following results:

Queries

Observed

	Trial 1	Trial 2	Sums
Criteria	1	203	204
Conventional	72	362	434
Sums	73	565	638

Estimated Expected

	Trial 1	Trial 2	Sums
Criteria	23.34169	180.6583	204
Conventional	49.65831	384.3417	434
Sums	73	565	638

ChiSquare: 35.49793 >= 3.84
Reject Ho at 5%. Dependence exists.

Appendix H: Objective Data Analysis Output
ANOVA Results

Task 1. Power up and Zero Return
Response variable: Time

Analysis of Variance for Time, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Method	1	1627.4	1627.4	1627.4	3.48	0.070
Delivery	1	2311.0	2311.0	2311.0	4.95	0.033
Run	1	23105.0	23105.0	23105.0	39.48	0.000
Method*Delivery	1	828.2	828.2	828.2	1.77	0.191
Method*Run	1	741.6	741.6	741.6	1.27	0.268
Delivery*Run	1	1042.7	1042.7	1042.7	1.78	0.190
Method*Delivery*Run	1	491.0	491.0	491.0	0.84	0.366
Subject(Method Delivery)	36	16818.9	16818.9	467.2	0.80	0.749
Error	36	21067.4	21067.4	585.2		
Total	79	68033.3				

Unusual Observations for Time

Obs	Time R1	Fit	StDev Fit	Residual	St Resid
3	42.910	88.883	17.941	-45.973	-2.83R
4	187.110	141.137	17.941	45.973	2.83R
11	52.520	91.718	17.941	-39.198	-2.42R
12	183.170	143.972	17.941	39.198	2.42R
79	44.490	83.523	17.941	-39.033	-2.41R
80	148.190	109.157	17.941	39.033	2.41R

R denotes an observation with a large standardized residual.

Task 2. Activate Stored Program
Response variable: Time

Analysis of Variance for Time, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Method	1	319.0	319.0	319.0	1.94	0.172
Delivery	1	18.5	18.5	18.5	0.11	0.739
Run	1	9056.3	9056.3	9056.3	60.72	0.000
Method*Delivery	1	106.1	106.1	106.1	0.65	0.427
Method*Run	1	0.8	0.8	0.8	0.01	0.943
Delivery*Run	1	0.3	0.3	0.3	0.00	0.964
Method*Delivery*Run	1	128.1	128.1	128.1	0.86	0.360
Subject(Method Delivery)	36	5915.2	5915.2	164.3	1.10	0.386
Error	36	5369.0	5369.0	149.1		
Total	79	20913.3				

Unusual Observations for Time

Obs	Time	Fit	StDev Fit	Residual	St Resid
69	6.3400	28.8710	9.0568	-22.5310	-2.75R
70	74.8900	52.3590	9.0568	22.5310	2.75R

R denotes an observation with a large standardized residual.

Task 3. Collet Open/Close
Response variable: Time

Analysis of Variance for Time, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Method	1	74.00	74.00	74.00	3.51	0.069
Delivery	1	21.72	21.72	21.72	1.03	0.317
Run	1	506.72	506.72	506.72	29.99	0.000
Method*Delivery	1	5.00	5.00	5.00	0.24	0.629
Method*Run	1	18.26	18.26	18.26	1.08	0.305
Delivery*Run	1	1.10	1.10	1.10	0.06	0.800
Method*Delivery*Run	1	5.26	5.26	5.26	0.31	0.580
Subject(Method Delivery)	36	758.59	758.59	21.07	1.25	0.255
Error	36	608.20	608.20	16.89		
Total	79	1998.84				

Unusual Observations for Time

Obs	Time	Fit	StDev Fit	Residual	St Resid
33	6.4900	14.8340	3.0483	-8.3440	-3.03R
34	28.4200	20.0760	3.0483	8.3440	3.03R
47	8.2700	15.8855	3.0483	-7.6155	-2.76R
48	27.3000	19.6845	3.0483	7.6155	2.76R

R denotes an observation with a large standardized residual.

Task 4. Make First Part

Response variable: Time

Analysis of Variance for Time, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Method	1	6406.8	6406.8	6406.8	15.50	0.000
Delivery	1	435.6	435.6	435.6	1.05	0.312
Run	1	16631.5	16631.5	16631.5	65.66	0.000
Method*Delivery	1	196.2	196.2	196.2	0.47	0.495
Method*Run	1	596.5	596.5	596.5	2.35	0.134
Delivery*Run	1	127.1	127.1	127.1	0.50	0.483
Method*Delivery*Run	1	7.9	7.9	7.9	0.03	0.861
Subject(Method Delivery)	36	14884.4	14884.4	413.5	1.63	0.073
Error	36	9119.4	9119.4	253.3		
Total	79	48405.2				

Unusual Observations for Time

Obs	Time	Fit	StDev Fit	Residual	St Resid
1	82.910	59.303	11.804	23.607	2.21R
2	68.100	91.707	11.804	-23.607	-2.21R
35	29.980	65.494	11.804	-35.514	-3.33R
36	137.200	101.686	11.804	35.514	3.33R

R denotes an observation with a large standardized residual.

Task 5. Power Down
Response variable: Time

Analysis of Variance for Time, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Method	1	302.91	302.91	302.91	7.45	0.010
Delivery	1	94.98	94.98	94.98	2.34	0.135
Run	1	1347.67	1347.67	1347.67	68.72	0.000
Method*Delivery	1	7.06	7.06	7.06	0.17	0.679
Method*Run	1	27.11	27.11	27.11	1.38	0.247
Delivery*Run	1	4.45	4.45	4.45	0.23	0.637
Method*Delivery*Run	1	28.55	28.55	28.55	1.46	0.235
Subject(Method Delivery)	36	1462.96	1462.96	40.64	2.07	0.016
Error	36	705.98	705.98	19.61		
Total	79	3981.68				

Unusual Observations for Time

Obs	Time	Fit	StDev Fit	Residual	St Resid
47	24.3600	30.9095	3.2842	-6.5495	-2.20R
48	46.1700	39.6205	3.2842	6.5495	2.20R

R denotes an observation with a large standardized residual.

Appendix I: Subjective Data Analysis Output-Tabulation and Boxplot Results

Task 1. Power Up and Zero Return

Response variable: Response 1

Tabulated Statistics: Response 1 vs. Method, Delivery, Trial

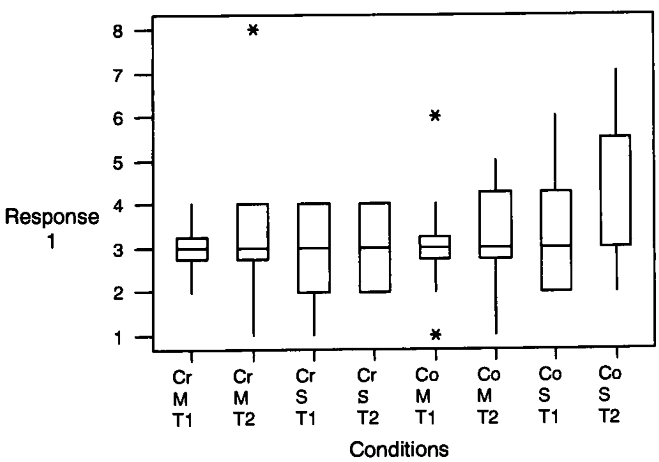
```
Control: Trial = 1
Rows: Method
Columns: Delivery
```

	M	S	All
Cr	3.0000	3.0000	3.0000
	4.0000	3.0000	--
	3.0000	4.0000	
	3.0000	4.0000	
	4.0000	4.0000	
	3.0000	3.0000	
	3.0000	3.0000	
	2.0000	1.0000	
	3.0000	4.0000	
	2.0000	2.0000	
	3.0000	2.0000	
Co	3.1000	3.2000	3.1500
	6.0000	3.0000	--
	1.0000	5.0000	
	4.0000	3.0000	
	3.0000	4.0000	
	2.0000	3.0000	
	3.0000	2.0000	
	3.0000	2.0000	
	3.0000	6.0000	
	3.0000	2.0000	
	3.0000	2.0000	
All	3.0500	3.1000	3.0750
	--	--	--

```
Control: Trial = 2
Rows: Method
Columns: Delivery
```

	M	S	All
Cr	3.4000	2.9000	3.1500
	3.0000	2.0000	--
	8.0000	2.0000	
	3.0000	4.0000	
	4.0000	4.0000	
	3.0000	3.0000	
	3.0000	2.0000	
	3.0000	3.0000	
	2.0000	4.0000	
	1.0000	3.0000	
	4.0000	2.0000	
Co	3.3000	4.0000	3.6500
	3.0000	3.0000	--
	2.0000	7.0000	
	5.0000	4.0000	
	1.0000	3.0000	
	3.0000	5.0000	
	3.0000	7.0000	
	3.0000	3.0000	
	4.0000	3.0000	
	5.0000	3.0000	
	4.0000	2.0000	
All	3.3500	3.4500	3.4000
	--	--	--

Boxplot of Response 1 vs. Method, Delivery, Trial:
(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 1. Power Up and Zero Return

Response variable: Response 3

Tabulated Statistics: Response 3 vs. Method, Delivery, Trial

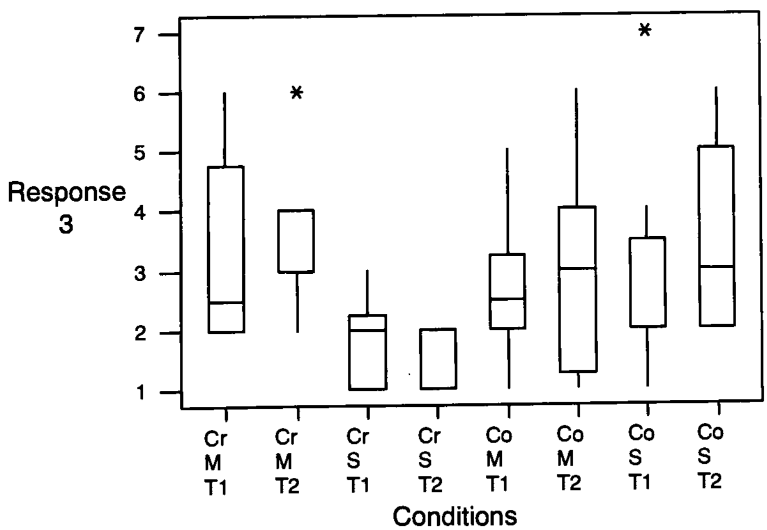
Control: Trial = 1
Rows: Method
Columns: Delivery

	M	S	All
Cr	3.2500	1.8333	2.6429
	5.0000	1.0000	--
	6.0000	2.0000	
	2.0000	1.0000	
	4.0000	2.0000	
	2.0000	2.0000	
	2.0000	3.0000	
	3.0000		
	2.0000		
Co	2.7000	2.8889	2.7895
	2.0000	3.0000	--
	3.0000	7.0000	
	3.0000	2.0000	
	1.0000	2.0000	
	2.0000	3.0000	
	4.0000	2.0000	
	3.0000	4.0000	
	2.0000	1.0000	
	2.0000	2.0000	
	5.0000		
All	2.9444	2.4667	2.7273
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	3.5714	1.6000	2.7500
	4.0000	1.0000	--
	6.0000	2.0000	
	3.0000	1.0000	
	4.0000	2.0000	
	2.0000	2.0000	
	3.0000		
	3.0000		
Co	3.0000	3.4286	3.2000
	1.0000	3.0000	--
	2.0000	4.0000	
	6.0000	5.0000	
	1.0000	2.0000	
	3.0000	6.0000	
	4.0000	2.0000	
	4.0000	2.0000	
	3.0000		
All	3.2667	2.6667	3.0000
	--	--	--

Boxplot of Response 3 vs. Method, Delivery, Trial:
(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 1. Power Up and Zero Return
Response variable: Response 4

Tabulated Statistics: Response 4 vs. Method, Delivery, Trial

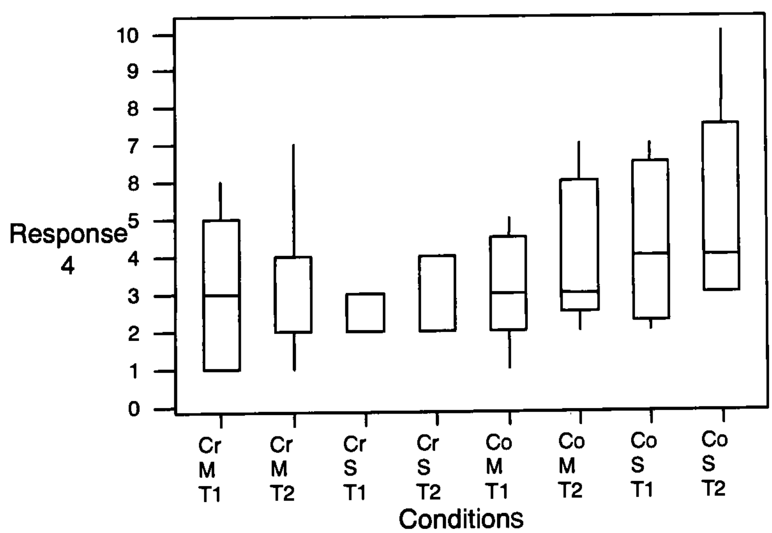
Control: Trial = 1
Rows: Method
Columns: Delivery

	M	S	All
Cr	3.2857	2.3333	3.0000
	3.0000	3.0000	--
	6.0000	2.0000	
	4.0000	2.0000	
	5.0000		
	3.0000		
	1.0000		
	1.0000		
Co	3.2000	4.2500	3.6667
	5.0000	2.0000	--
	4.0000	7.0000	
	3.0000	3.0000	
	3.0000	5.0000	
	1.0000		
All	3.2500	3.4286	3.3158
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	3.0000	2.7778	2.8889
	3.0000	3.0000	--
	7.0000	2.0000	
	2.0000	4.0000	
	2.0000	4.0000	
	2.0000	4.0000	
	4.0000	2.0000	
	1.0000	2.0000	
	2.0000	2.0000	
	4.0000	2.0000	
Co	4.0000	5.0000	4.5000
	5.0000	4.0000	--
	2.0000	5.0000	
	3.0000	3.0000	
	3.0000	10.0000	
	7.0000	3.0000	
All	3.3571	3.5714	3.4643
	--	--	--

Boxplot of Response 4 vs. Method, Delivery, Trial:
(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 1. Power Up and Zero Return
Response variable: Response 6

Tabulated Statistics: Response 6 vs. Method, Delivery, Trial

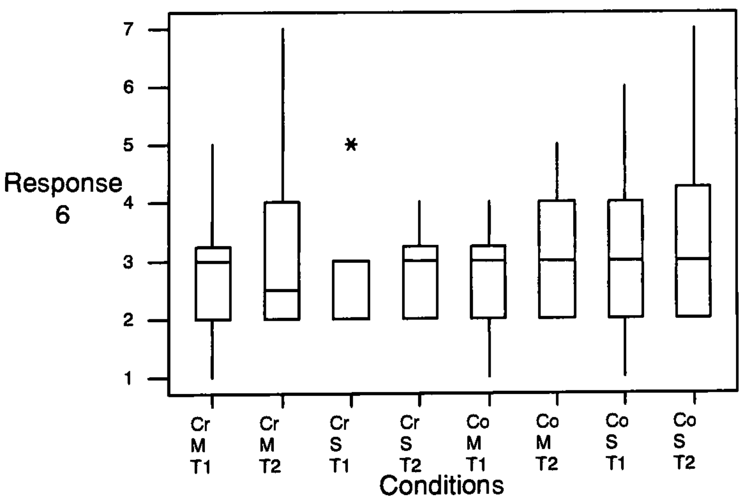
Control: Trial = 1
Rows: Method
Columns: Delivery

	M	S	All
Cr	2.9000	2.8000	2.8500
	5.0000	3.0000	--
	3.0000	3.0000	
	2.0000	3.0000	
	4.0000	5.0000	
	3.0000	2.0000	
	3.0000	3.0000	
	2.0000	2.0000	
	3.0000	2.0000	
	1.0000	3.0000	
	3.0000	2.0000	
Co	2.7000	3.0000	2.8500
	4.0000	4.0000	--
	1.0000	6.0000	
	4.0000	1.0000	
	2.0000	4.0000	
	2.0000	3.0000	
	3.0000	3.0000	
	3.0000	2.0000	
	2.0000	3.0000	
	3.0000	2.0000	
	3.0000	2.0000	
All	2.8000	2.9000	2.8500
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	3.1000	2.8000	2.9500
	3.0000	2.0000	--
	7.0000	2.0000	
	3.0000	4.0000	
	2.0000	4.0000	
	2.0000	3.0000	
	4.0000	2.0000	
	2.0000	3.0000	
	2.0000	3.0000	
	2.0000	3.0000	
	4.0000	2.0000	
Co	3.2000	3.4000	3.3000
	3.0000	2.0000	--
	2.0000	5.0000	
	5.0000	4.0000	
	2.0000	3.0000	
	3.0000	3.0000	
	2.0000	7.0000	
	3.0000	3.0000	
	4.0000	2.0000	
	4.0000	3.0000	
	4.0000	2.0000	
All	3.1500	3.1000	3.1250
	--	--	--

Boxplot of Response 6 vs. Method, Delivery, Trial:
(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 2. Activate Stored Program

Response variable: Response 1

Tabulated Statistics: Response 1 vs. Method, Delivery, Trial

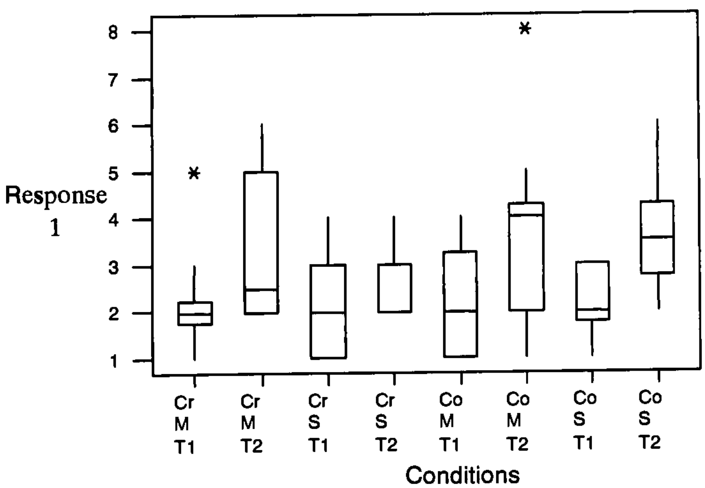
Control: Trial = 1
Rows: Method
Columns: Delivery

	M	S	All
Cr	2.2000	2.2000	2.2000
	5.0000	1.0000	--
	2.0000	4.0000	
	2.0000	3.0000	
	2.0000	3.0000	
	2.0000	1.0000	
	2.0000	1.0000	
	1.0000	2.0000	
	3.0000	3.0000	
	1.0000	2.0000	
	2.0000	2.0000	
Co	2.3000	2.2000	2.2500
	4.0000	3.0000	--
	1.0000	2.0000	
	3.0000	2.0000	
	4.0000	3.0000	
	2.0000	2.0000	
	2.0000	3.0000	
	1.0000	1.0000	
	3.0000	3.0000	
	2.0000	2.0000	
	1.0000	1.0000	
All	2.2500	2.2000	2.2250
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	3.2000	2.8000	3.0000
	6.0000	2.0000	--
	2.0000	3.0000	
	3.0000	3.0000	
	5.0000	4.0000	
	2.0000	2.0000	
	5.0000	3.0000	
	3.0000	3.0000	
	2.0000	2.0000	
	2.0000	3.0000	
	2.0000	3.0000	
Co	3.7000	3.6000	3.6500
	5.0000	4.0000	--
	1.0000	6.0000	
	8.0000	2.0000	
	3.0000	4.0000	
	4.0000	3.0000	
	2.0000	5.0000	
	2.0000	3.0000	
	4.0000	4.0000	
	4.0000	3.0000	
	4.0000	2.0000	
All	3.4500	3.2000	3.3250
	--	--	--

Boxplot of Response 1 vs. Method, Delivery, Trial:
(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 2. Activate Stored Program

Response variable: Response 2

Tabulated Statistics: Response 2 vs. Method, Delivery, Trial

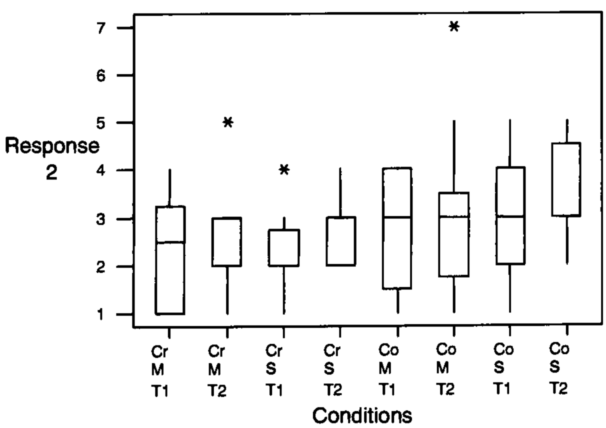
Control: Trial = 1
Rows: Method
Columns: Delivery

	M	S	All
Cr	2.4000	2.2500	2.3333
	4.0000	1.0000	--
	1.0000	2.0000	
	2.0000	4.0000	
	4.0000	2.0000	
	3.0000	2.0000	
	3.0000	2.0000	
	1.0000	2.0000	
	2.0000	3.0000	
	1.0000		
	3.0000		
Co	2.6667	2.8889	2.7778
	1.0000	4.0000	--
	2.0000	5.0000	
	4.0000	4.0000	
	3.0000	2.0000	
	2.0000	3.0000	
	1.0000	1.0000	
	4.0000	3.0000	
	4.0000	2.0000	
	3.0000	2.0000	
All	2.5263	2.5882	2.5556
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	2.8000	2.6667	2.7368
	5.0000	2.0000	--
	3.0000	2.0000	
	3.0000	4.0000	
	3.0000	2.0000	
	3.0000	3.0000	
	3.0000	3.0000	
	3.0000	2.0000	
	2.0000	3.0000	
	1.0000	3.0000	
	2.0000		
Co	3.0000	3.4444	3.2105
	1.0000	3.0000	--
	1.0000	5.0000	
	7.0000	5.0000	
	3.0000	3.0000	
	3.0000	3.0000	
	2.0000	3.0000	
	2.0000	3.0000	
	3.0000	4.0000	
	3.0000	2.0000	
	5.0000		
All	2.9000	3.0556	2.9737
	--	--	--

Boxplot of Response 2 vs. Method, Delivery, Trial:
(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 2. Activate Stored Program
Response variable: Response 3

Tabulated Statistics: Response 3 vs. Method, Delivery, Trial

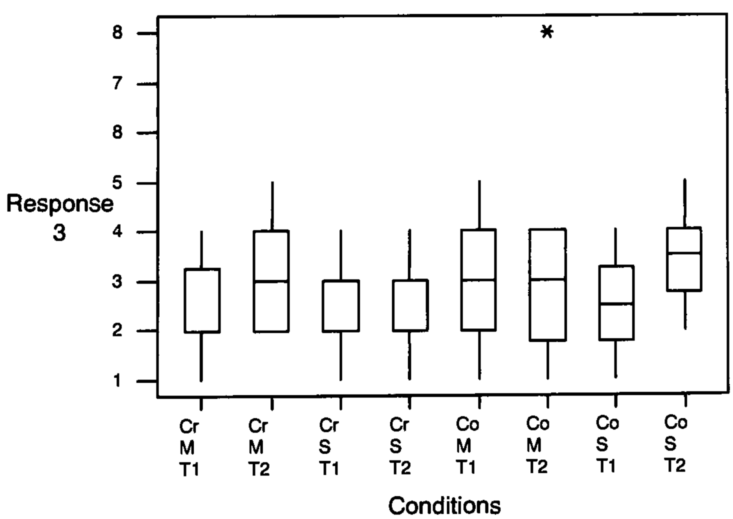
```
Control: Trial = 1
Rows: Method
Columns: Delivery
```

	M	S	All
Cr	2.5000	2.3750	2.4444
	3.0000	2.0000	--
	2.0000	2.0000	
	2.0000	4.0000	
	4.0000	1.0000	
	4.0000	2.0000	
	3.0000	3.0000	
	1.0000	3.0000	
	2.0000	2.0000	
	2.0000		
	2.0000		
Co	3.0000	2.5000	2.7222
	1.0000	2.0000	--
	2.0000	4.0000	
	4.0000	3.0000	
	4.0000	3.0000	
	2.0000	2.0000	
	3.0000	3.0000	
	3.0000	1.0000	
	5.0000	4.0000	
		1.0000	
		2.0000	
All	2.7222	2.4444	2.5833
	--	--	--

```
Control: Trial = 2
Rows: Method
Columns: Delivery
```

	M	S	All
Cr	3.2000	2.5556	2.8947
	5.0000	1.0000	--
	4.0000	2.0000	
	3.0000	3.0000	
	4.0000	2.0000	
	3.0000	4.0000	
	4.0000	3.0000	
	2.0000	3.0000	
	2.0000	2.0000	
	2.0000	3.0000	
	3.0000		
Co	3.2000	3.4000	3.3000
	1.0000	2.0000	--
	1.0000	4.0000	
	8.0000	4.0000	
	3.0000	3.0000	
	4.0000	4.0000	
	3.0000	5.0000	
	2.0000	3.0000	
	3.0000	4.0000	
	3.0000	3.0000	
	4.0000	2.0000	
All	3.2000	3.0000	3.1026
	--	--	--

Boxplot of Response 3 vs. Method, Delivery, Trial:
(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 2. Activate Stored Program
Response variable: Response 4

Tabulated Statistics: Response 4 vs. Method, Delivery, Trial

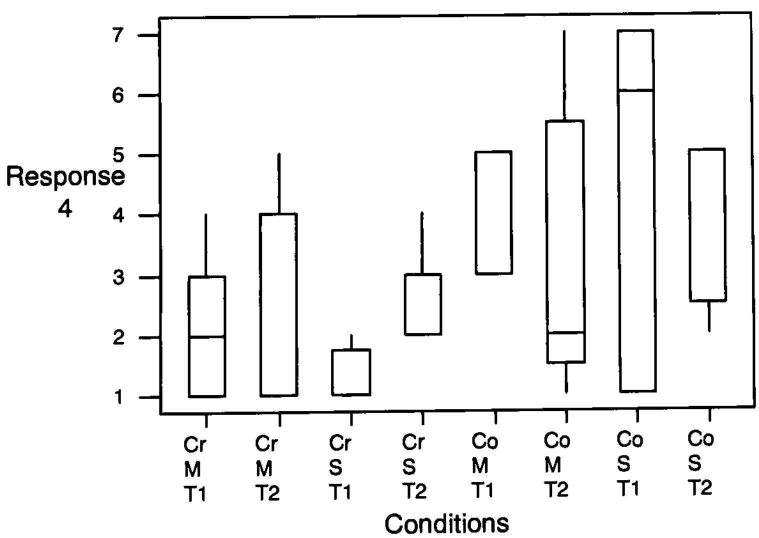
Control: Trial = 1
Rows: Method
Columns: Delivery

	M	S	All
Cr	2.0000	1.2500	1.7273
	2.0000	1.0000	--
	2.0000	2.0000	
	4.0000	1.0000	
	1.0000	1.0000	
	3.0000		
	1.0000		
	1.0000		
Co	3.6667	4.6667	4.1667
	3.0000	1.0000	--
	5.0000	7.0000	
	3.0000	6.0000	
All	2.5000	2.7143	2.5882
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	3.0000	2.5714	2.7857
	4.0000	2.0000	--
	4.0000	2.0000	
	2.0000	3.0000	
	4.0000	2.0000	
	5.0000	3.0000	
	1.0000	2.0000	
	1.0000	4.0000	
Co	3.2000	4.0000	3.6000
	4.0000	5.0000	--
	1.0000	2.0000	
	7.0000	5.0000	
	2.0000	3.0000	
	2.0000	5.0000	
All	3.0833	3.1667	3.1250
	--	--	--

Boxplot of Response 4 vs. Method, Delivery, Trial:
(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 2. Activate Stored Program
Response variable: Response 5

Tabulated Statistics: Response 5 vs. Method, Delivery, Trial

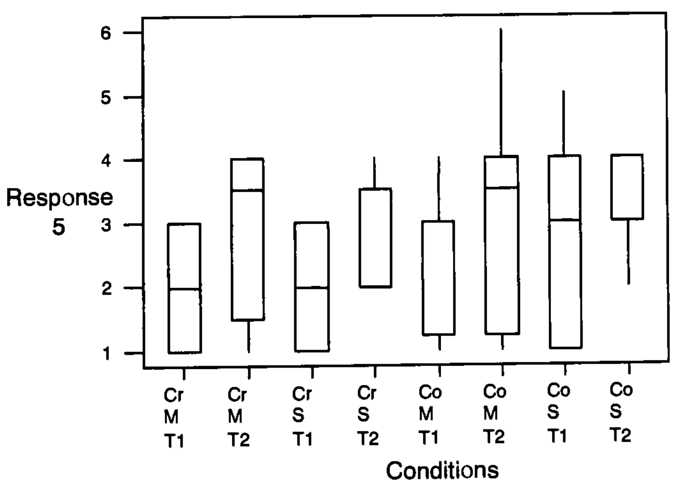
Control: Trial = 1
Rows: Method
Columns: Delivery

	M	S	All
Cr	2.1111 3.0000 3.0000 3.0000 2.0000 1.0000 3.0000 1.0000 2.0000 1.0000	1.8571 1.0000 2.0000 3.0000 1.0000 1.0000 3.0000 2.0000	2.0000 --
Co	2.5000 1.0000 3.0000 4.0000 3.0000 2.0000 3.0000 3.0000 1.0000	2.7000 3.0000 5.0000 3.0000 3.0000 1.0000 4.0000 1.0000 4.0000 1.0000 2.0000	2.6111 --
All	2.2941 --	2.3529 --	2.3235 --

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	3.0000 4.0000 3.0000 3.0000 4.0000 4.0000 4.0000 1.0000 1.0000	2.6667 2.0000 2.0000 4.0000 4.0000 2.0000 2.0000 3.0000 2.0000 3.0000	2.8235 --
Co	3.1250 1.0000 1.0000 6.0000 4.0000 3.0000 2.0000 4.0000 4.0000	3.1429 3.0000 4.0000 4.0000 3.0000 3.0000 2.0000 3.0000	3.1333 --
All	3.0625 --	2.8750 --	2.9687 --

Boxplot of Response 5 vs. Method, Delivery, Trial:
(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 2. Activate Stored Program
Response variable: Response 6

Tabulated Statistics: Response 6 vs. Method, Delivery, Trial

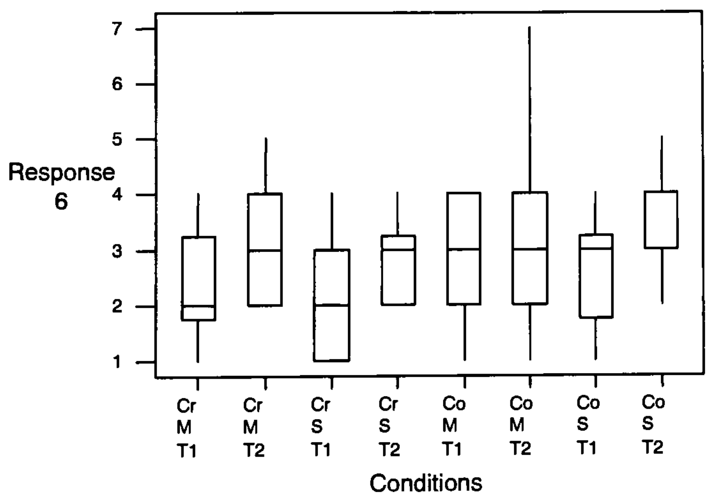
Control: Trial = 1
Rows: Method
Columns: Delivery

	M	S	All
Cr	2.4000	2.1000	2.2500
	4.0000	1.0000	--
	2.0000	2.0000	
	2.0000	4.0000	
	3.0000	3.0000	
	4.0000	1.0000	
	3.0000	1.0000	
	1.0000	2.0000	
	2.0000	3.0000	
	1.0000	2.0000	
	2.0000	2.0000	
Co	2.8000	2.6000	2.7000
	4.0000	3.0000	--
	1.0000	3.0000	
	4.0000	3.0000	
	3.0000	4.0000	
	2.0000	1.0000	
	2.0000	4.0000	
	2.0000	1.0000	
	3.0000	3.0000	
	4.0000	2.0000	
	3.0000	2.0000	
All	2.6000	2.3500	2.4750
	--	--	--

Control: Trial = r
Rows: Method
Columns: Delivery

	M	S	All
Cr	3.0000	2.9000	2.9500
	5.0000	2.0000	--
	3.0000	3.0000	
	3.0000	4.0000	
	4.0000	4.0000	
	3.0000	2.0000	
	4.0000	3.0000	
	2.0000	3.0000	
	2.0000	3.0000	
	2.0000	2.0000	
	2.0000	3.0000	
Co	3.2000	3.3000	3.2500
	3.0000	3.0000	--
	1.0000	5.0000	
	7.0000	4.0000	
	3.0000	3.0000	
	4.0000	3.0000	
	2.0000	3.0000	
	2.0000	3.0000	
	3.0000	4.0000	
	3.0000	3.0000	
	4.0000	2.0000	
All	3.1000	3.1000	3.1000
	--	--	--

Boxplot of Response 6 vs. Method, Delivery, Trial:
(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 3. Collet Open/Close

Response variable: Response 1

Tabulated Statistics: Response 1 vs. Method, Delivery, Trial

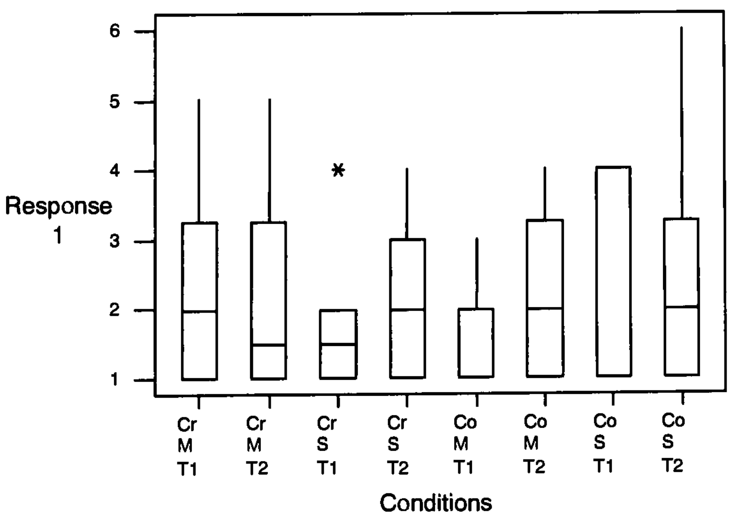
Control: Trial = 1
Rows: Method
Columns: Delivery

	M	S	All
Cr	2.4000	1.7000	2.0500
	5.0000	1.0000	--
	4.0000	2.0000	
	1.0000	2.0000	
	2.0000	2.0000	
	3.0000	1.0000	
	2.0000	4.0000	
	3.0000	1.0000	
	1.0000	2.0000	
	1.0000	1.0000	
	2.0000	1.0000	
Co	1.7000	2.0000	1.8500
	2.0000	4.0000	--
	1.0000	4.0000	
	2.0000	1.0000	
	1.0000	4.0000	
	1.0000	1.0000	
	1.0000	1.0000	
	2.0000	1.0000	
	2.0000	2.0000	
	3.0000	1.0000	
	2.0000	1.0000	
All	2.0500	1.8500	1.9500
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	2.2000	2.1000	2.1500
	4.0000	1.0000	--
	1.0000	3.0000	
	3.0000	2.0000	
	1.0000	4.0000	
	3.0000	1.0000	
	5.0000	3.0000	
	2.0000	1.0000	
	1.0000	3.0000	
	1.0000	1.0000	
	1.0000	2.0000	
Co	2.3000	2.4000	2.3500
	2.0000	2.0000	--
	1.0000	6.0000	
	2.0000	1.0000	
	2.0000	2.0000	
	4.0000	1.0000	
	1.0000	4.0000	
	3.0000	3.0000	
	3.0000	1.0000	
	1.0000	3.0000	
	4.0000	1.0000	
All	2.2500	2.2500	2.2500
	--	--	--

Boxplot of Response 1 vs. Method, Delivery, Trial:
(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 3. Collet Open/Close
Response Variable: Response 4

Tabulated Statistics: Response 4 vs. Method, Delivery, Trial

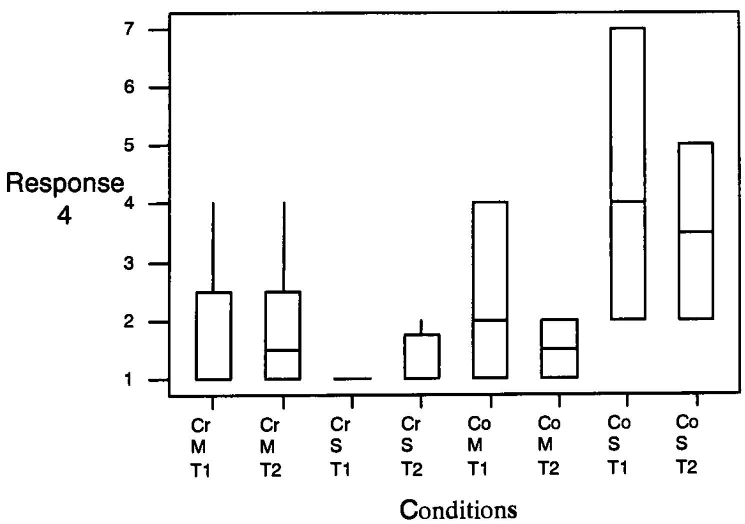
Control: Trial = 1
Rows: Method
Columns: Delivery

	M	S	All
Cr	1.6667	1.0000	1.4444
	4.0000	1.0000	--
	1.0000	1.0000	
	2.0000	1.0000	
	1.0000		
	1.0000		
	1.0000		
Co	2.3333	4.3333	3.3333
	1.0000	4.0000	--
	2.0000	7.0000	
	4.0000	2.0000	
All	1.8889	2.6667	2.2000
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	1.8333	1.2500	1.6000
	2.0000	1.0000	--
	1.0000	1.0000	
	1.0000	1.0000	
	4.0000	2.0000	
	1.0000		
	2.0000		
Co	1.5000	3.5000	2.5000
	1.0000	5.0000	--
	2.0000	2.0000	
All	1.7500	2.0000	1.8571
	--	--	--

Boxplot of Response 4 vs. Method, Delivery, Trial:
(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 3. Collet Open/Close
Response Variable: Response 6

Tabulated Statistics: Response 6 vs. Method, Delivery, Trial

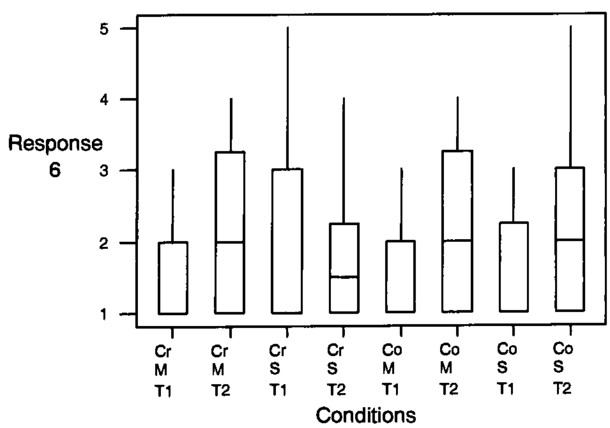
Control: Trial = 1
Rows: Method
Columns: Delivery

	M	S	All
Cr	1.8000	1.8000	1.8000
	3.0000	1.0000	--
	2.0000	1.0000	
	1.0000	5.0000	
	2.0000	3.0000	
	2.0000	1.0000	
	2.0000	3.0000	
	2.0000	1.0000	
	1.0000	1.0000	
	1.0000	1.0000	
	2.0000	1.0000	
Co	1.7000	1.5000	1.6000
	2.0000	3.0000	--
	1.0000	3.0000	
	2.0000	1.0000	
	1.0000	1.0000	
	1.0000	1.0000	
	2.0000	1.0000	
	2.0000	1.0000	
	1.0000	2.0000	
	3.0000	1.0000	
	2.0000	1.0000	
All	1.7500	1.6500	1.7000
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	2.2000	1.8000	2.0000
	4.0000	1.0000	--
	1.0000	2.0000	
	3.0000	2.0000	
	2.0000	4.0000	
	3.0000	1.0000	
	4.0000	3.0000	
	2.0000	1.0000	
	1.0000	1.0000	
	1.0000	1.0000	
	1.0000	2.0000	
Co	2.2000	2.2000	2.2000
	2.0000	2.0000	--
	1.0000	5.0000	
	2.0000	1.0000	
	1.0000	2.0000	
	4,0000	1.0000	
	1.0000	2.0000	
	3.0000	3.0000	
	3.0000	2.0000	
	1.0000	3.0000	
	4.0000	1.0000	
All	2.2000	2.0000	2.1000
	--	--	--

Boxplot of Response 6 vs. Method, Delivery, Trial:
(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 4. Make First Part
Response variable: Response 1

Tabulated Statistics: Response 1 vs. Method, Delivery, Trial

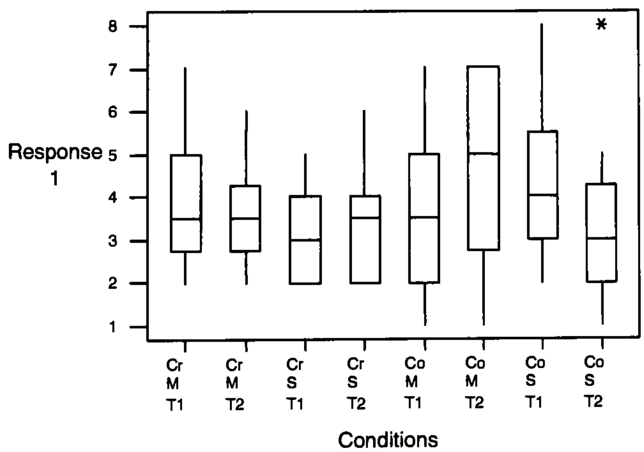
Control: Trial = 1
Rows: Method
Columns: Delivery

	M	S	All
Cr	3.8000	3.1000	3.4500
	7.0000	4.0000	--
	4.0000	5.0000	
	3.0000	3.0000	
	5.0000	4.0000	
	5.0000	3.0000	
	3.0000	3.0000	
	3.0000	3.0000	
	2.0000	2.0000	
	2.0000	2.0000	
	4.0000	2.0000	
Co	3.7000	4.3000	4.0000
	7.0000	4.0000	--
	1.0000	7.0000	
	5.0000	3.0000	
	5.0000	5.0000	
	3.0000	4.0000	
	4.0000	8.0000	
	2.0000	3.0000	
	3.0000	4.0000	
	5.0000	2.0000	
	2.0000	3.0000	
All	3.7500	3.7000	3.7250
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	3.6000	3.4000	3.5000
	6.0000	3.0000	--
	4.0000	4.0000	
	4.0000	4.0000	
	3.0000	4.0000	
	5.0000	2.0000	
	4.0000	2.0000	
	2.0000	3.0000	
	3.0000	6.0000	
	2.0000	4.0000	
	3.0000	2.0000	
Co	4.6000	3.5000	4.0500
	6.0000	2.0000	--
	1.0000	4.0000	
	7.0000	1.0000	
	3.0000	3.0000	
	5.0000	5.0000	
	3.0000	8.0000	
	2.0000	3.0000	
	7.0000	4.0000	
	7.0000	3.0000	
	5.0000	2.0000	
All	4.1000	3.4500	3.7750
	--	--	--

Boxplot of Response 1 vs. Method, Delivery, Trial:
(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 4. Make First Part

Response variable: Response 2

Tabulated Statistics: Response 2 vs. Method, Delivery, Trial

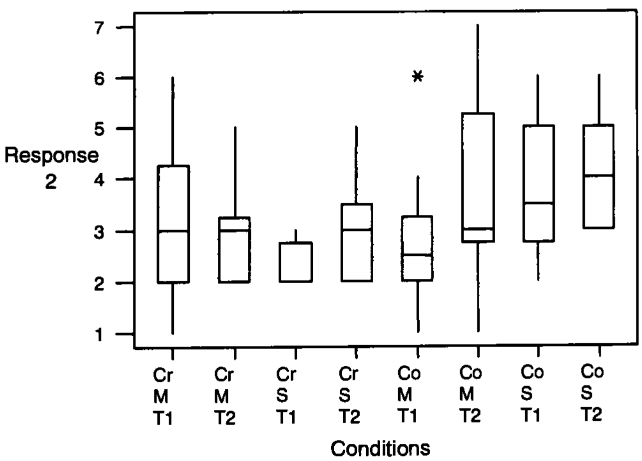
Control: Trial = 1
Rows: Method
Columns: Delivery

	M	S	All
Cr	3.2000	2.2500	2.7778
	6.0000	2.0000	--
	4.0000	2.0000	
	2.0000	3.0000	
	3.0000	2.0000	
	5.0000	2.0000	
	4.0000	2.0000	
	2.0000	3.0000	
	2.0000	2.0000	
	1.0000		
	3.0000		
Co	2.8000	3.7000	3.2500
	2.0000	5.0000	--
	1.0000	5.0000	
	6.0000	3.0000	
	3.0000	3.0000	
	2.0000	4.0000	
	3.0000	6.0000	
	3.0000	2.0000	
	2.0000	4.0000	
	4.0000	2.0000	
	2.0000	3.0000	
All	3.0000	3.0556	3.0263
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	2.9000	3.0000	2.9500
	5.0000	3.0000	--
	3.0000	2.0000	
	3.0000	3.0000	
	2.0000	5.0000	
	3.0000	3.0000	
	4.0000	3.0000	
	2.0000	2.0000	
	2.0000	5.0000	
	2.0000	2.0000	
	3.0000	2.0000	
Co	3.8000	4.1000	3.9500
	2.0000	3.0000	--
	1.0000	4.0000	
	6.0000	3.0000	
	3.0000	4.0000	
	3.0000	4.0000	
	3.0000	6.0000	
	3.0000	5.0000	
	5.0000	5.0000	
	7.0000	4.0000	
	5.0000	3.0000	
All	3.3500	3.5500	3.4500
	--	--	--

Boxplot of Response 2 vs. Method, Delivery, Trial:
(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 4. Make First Part
Response variable: Response 3

Tabulated Statistics: Response 3 vs. Method, Delivery, Trial

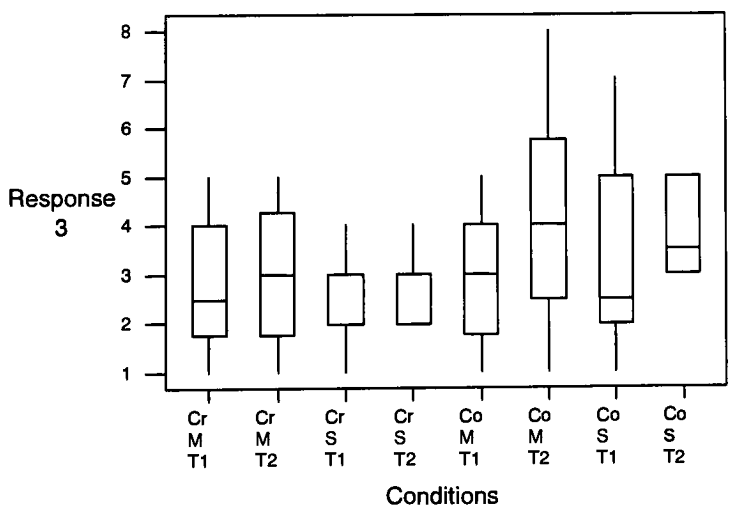
Control: Trial = 1
Rows: Method
Columns: Delivery

	M	S	All
Cr	2.8000	2.3000	2.5500
	5.0000	3.0000	--
	4.0000	2.0000	
	2.0000	2.0000	
	2.0000	4.0000	
	4.0000	2.0000	
	4.0000	3.0000	
	1.0000	2.0000	
	2.0000	2.0000	
	1.0000	1.0000	
	3.0000	2.0000	
Co	2.8000	3.3000	3.0500
	1.0000	4.0000	--
	1.0000	7.0000	
	4.0000	2.0000	
	3.0000	3.0000	
	2.0000	2.0000	
	2.0000	5.0000	
	4.0000	2.0000	
	3.0000	5.0000	
	5.0000	1.0000	
	3.0000	2.0000	
All	2.8000	2.8000	2.8000
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	3.1000	2.4000	2.7500
	5.0000	2.0000	--
	5.0000	2.0000	
	3.0000	3.0000	
	3.0000	4.0000	
	4.0000	2.0000	
	4.0000	3.0000	
	1.0000	2.0000	
	2.0000	2.0000	
	1.0000	2.0000	
	3.0000	2.0000	
Co	4.1000	3.8000	3.9500
	1.0000	3.0000	--
	1.0000	4.0000	
	8.0000	3.0000	
	4.0000	3.0000	
	3.0000	5.0000	
	4.0000	5.0000	
	3.0000	3.0000	
	4.0000	4.0000	
	8.0000	5.0000	
	5.0000	3.0000	
All	3.6000	3.1000	3.3500
	--	--	--

Boxplot of Response 3 vs. Method, Delivery, Trial:
(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 4. Make First Part

Response variable: Response 4

Tabulated Statistics: Response 4 vs. Method, Delivery, Trial

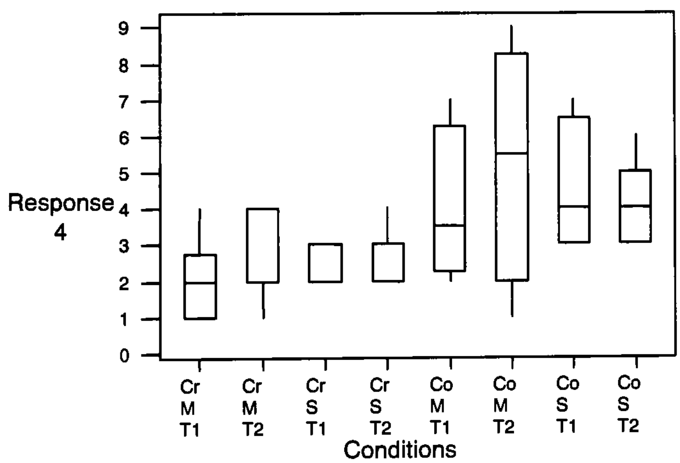
Control: Trial = 1
Rows: Method
Columns: Delivery

	M	S	All
Cr	2.0000	2.6000	2.2308
	3.0000	2.0000	--
	2.0000	3.0000	
	2.0000	3.0000	
	1.0000	2.0000	
	4.0000	3.0000	
	2.0000		
	1.0000		
	1.0000		
Co	4.0000	4.6000	4.3333
	3.0000	4.0000	--
	7.0000	7.0000	
	2.0000	3.0000	
	4.0000	6.0000	
		3.0000	
All	2.6667	3.6000	3.0909
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	2.7143	2.5714	2.6429
	4.0000	3.0000	--
	2.0000	3.0000	
	4.0000	2.0000	
	2.0000	2.0000	
	1.0000	2.0000	
	2.0000	4.0000	
	4.0000	2.0000	
Co	5.2500	4.2857	4.6364
	9.0000	4.0000	--
	1.0000	5.0000	
	5.0000	3.0000	
	6.0000	4.0000	
		6.0000	
		5.0000	
		3.0000	
All	3.6364	3.4286	3.5200
	--	--	--

Boxplot of Response 4 vs. Method, Delivery, Trial:
(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 4. Make First Part
Response variable: Response 5

Tabulated Statistics: Response 5 vs. Method, Delivery, Trial

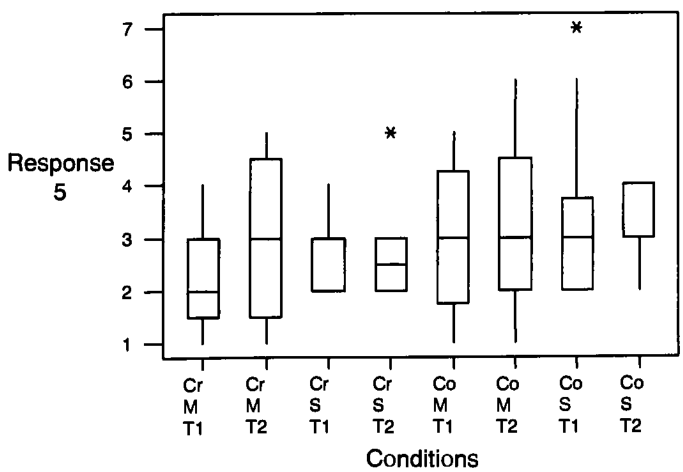
Control: Trial = 1
Rows: Method
Columns: Delivery

	M	S	All
Cr	2.2222	2.7000	2.4737
	4.0000	3.0000	--
	3.0000	2.0000	
	2.0000	3.0000	
	2.0000	4.0000	
	1.0000	2.0000	
	3.0000	3.0000	
	2.0000	2.0000	
	2.0000	3.0000	
	1.0000	3.0000	
		2.0000	
Co	3.1000	3.4000	3.2500
	1.0000	3.0000	--
	1.0000	6.0000	
	4.0000	2.0000	
	5.0000	3.0000	
	2.0000	3.0000	
	3.0000	7.0000	
	5.0000	2.0000	
	3.0000	3.0000	
	4.0000	2.0000	
	3.0000	3.0000	
All	2.6842	3.0500	2.8718
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	2.8889	2.7000	2.7895
	5.0000	3.0000	--
	4.0000	2.0000	
	3.0000	3.0000	
	2.0000	5.0000	
	3.0000	2.0000	
	5.0000	2.0000	
	1.0000	2.0000	
	2.0000	3.0000	
	1.0000	3.0000	
		2.0000	
Co	3.3333	3.3333	3.3333
	2.0000	3.0000	--
	1.0000	4.0000	
	5.0000	3.0000	
	4.0000	4.0000	
	3.0000	4.0000	
	3.0000	4.0000	
	2.0000	3.0000	
	6.0000	2.0000	
	4.0000	3.0000	
All	3.1111	3.0000	3.0541
	--	--	--

Boxplot of Response 5 vs. Method, Delivery, Trial:
(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 4. Make First Part

Response variable: Response 6

Tabulated Statistics: Response 6 vs. Method, Delivery, Trial

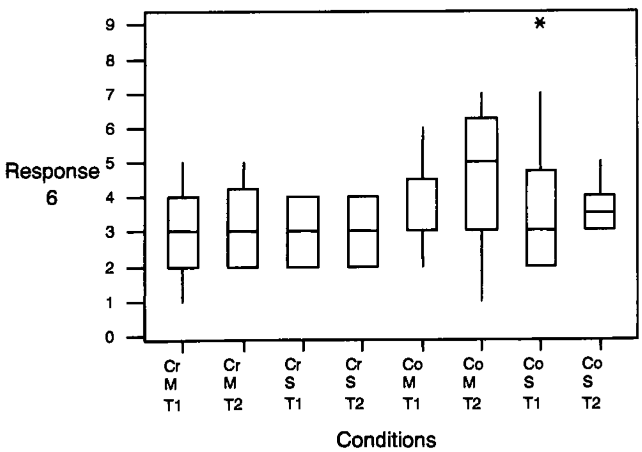
Control: Trial = 1
Rows: Method
Columns: Delivery

	M	S	All
Cr	2.9000	2.9000	2.9000
	5.0000	3.0000	--
	4.0000	4.0000	
	2.0000	4.0000	
	3.0000	4.0000	
	4.0000	2.0000	
	3.0000	3.0000	
	2.0000	2.0000	
	2.0000	3.0000	
	1.0000	2.0000	
	3.0000	2.0000	
Co	3.7000	3.9000	3.8000
	6.0000	4.0000	--
	3.0000	7.0000	
	6.0000	2.0000	
	3.0000	3.0000	
	2.0000	3.0000	
	3.0000	9.0000	
	4.0000	2.0000	
	3.0000	4.0000	
	4.0000	2.0000	
	3.0000	3.0000	
All	3.3000	3.4000	3.3500
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	3.3000	3.1000	3.2000
	5.0000	3.0000	--
	5.0000	4.0000	
	3.0000	4.0000	
	3.0000	4.0000	
	4.0000	2.0000	
	4.0000	2.0000	
	2.0000	3.0000	
	2.0000	4.0000	
	2.0000	3.0000	
	3.0000	2.0000	
Co	4.5000	3.6000	4.0500
	7.0000	3.0000	--
	1.0000	4.0000	
	5.0000	3.0000	
	3.0000	3.0000	
	5.0000	3.0000	
	3.0000	5.0000	
	3.0000	4.0000	
	6.0000	4.0000	
	7.0000	4.0000	
	5.0000	3.0000	
All	3.9000	3.3500	3.6250
	--	--	--

Boxplot of Response 6 vs. Method, Delivery, Trial:
(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 5. Power Down
Response variable: Response 1

Tabulated Statistics: Response 1 vs. Method, Delivery, Trial

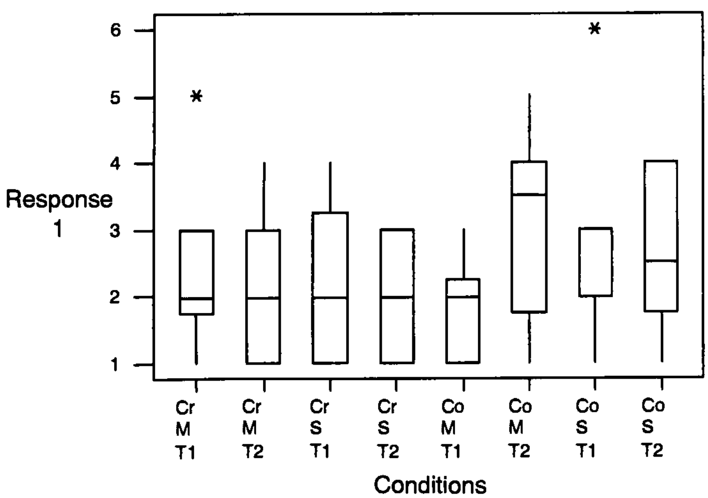
Control: Trial = 1
Rows: Method
Columns: Delivery

	M	S	All
Cr	2.3000	2.2000	2.2500
	5.0000	3.0000	--
	3.0000	4.0000	
	2.0000	3.0000	
	2.0000	2.0000	
	2.0000	2.0000	
	3.0000	1.0000	
	1.0000	1.0000	
	2.0000	4.0000	
	1.0000	1.0000	
	2.0000	1.0000	
Co	1.9000	2.5000	2.2000
	3.0000	2.0000	--
	1.0000	2.0000	
	3.0000	1.0000	
	2.0000	2.0000	
	1.0000	2.0000	
	1.0000	2.0000	
	2.0000	3.0000	
	2.0000	6.0000	
	2.0000	2.0000	
	2.0000	3.0000	
All	2.1000	2.3500	2.2250
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	2.1000	2.0000	2.0500
	3.0000	2.0000	--
	2.0000	1.0000	
	3.0000	3.0000	
	2.0000	3.0000	
	2.0000	1.0000	
	4.0000	2.0000	
	1.0000	2.0000	
	1.0000	3.0000	
	1.0000	1.0000	
	2.0000	2.0000	
Co	3.1000	2.6000	2.8500
	4.0000	1.0000	--
	1.0000	4.0000	
	2.0000	1.0000	
	1.0000	2.0000	
	4.0000	2.0000	
	4.0000	4.0000	
	3.0000	3.0000	
	4.0000	4.0000	
	3.0000	2.0000	
	5.0000	3.0000	
All	2.6000	2.3000	2.4500
	--	--	--

Boxplot of Response 1 vs. Method, Delivery, Trial:
(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Response variable: Response 3

Tabulated Statistics: Response 3 vs. Method, Delivery, Trial

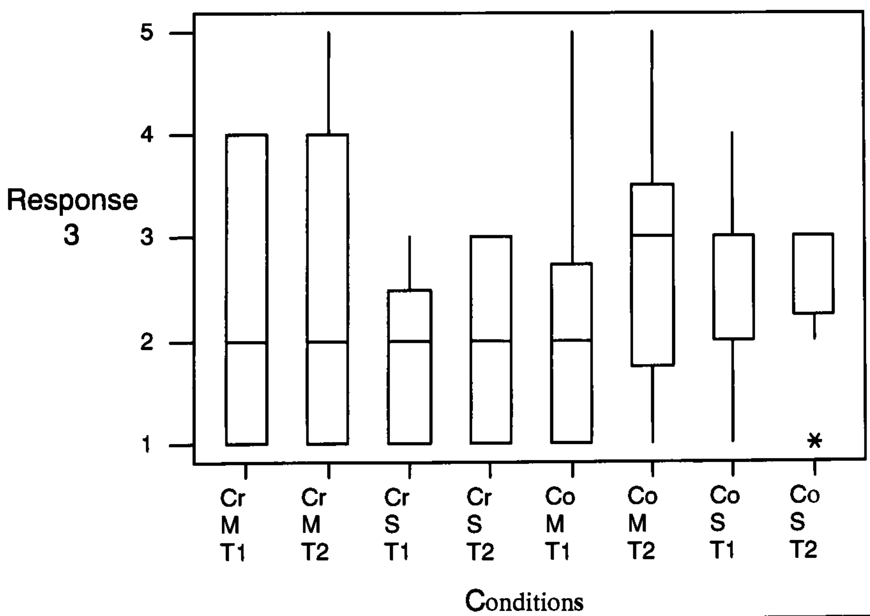
```
Control: Trial = 1
Rows: Method
Columns: Delivery
```

	M	S	All
Cr	2.1429	1.8000	2.0000
	4.0000	3.0000	--
	2.0000	2.0000	
	4.0000	1.0000	
	1.0000	1.0000	
	1.0000	2.0000	
	2.0000		
	1.0000		
Co	2.1667	2.5556	2.4000
	1.0000	3.0000	--
	1.0000	3.0000	
	2.0000	3.0000	
	2.0000	2.0000	
	2.0000	1.0000	
	5.0000	4.0000	
		2.0000	
		3.0000	
		2.0000	
All	2.1538	2.2857	2.2222
	--	--	--

```
Control: Trial = 2
Rows: Method
Columns: Delivery
```

	M	S	All
Cr	2.5714	2.0000	2.3333
	4.0000	1.0000	--
	3.0000	3.0000	
	2.0000	1.0000	
	2.0000	3.0000	
	5.0000	2.0000	
	1.0000		
	1.0000		
Co	2.8333	2.6250	2.7143
	3.0000	2.0000	--
	1.0000	3.0000	
	2.0000	1.0000	
	3.0000	3.0000	
	5.0000	3.0000	
	3.0000	3.0000	
		3.0000	
		3.0000	
All	2.6923	2.3846	2.5385
	--	--	--

Boxplot of Response 3 vs. Method, Delivery, Trial:
(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 5. Power Down

Response variable: Response 4

Tabulated Statistics: Response 4 vs. Method, Delivery, Trial

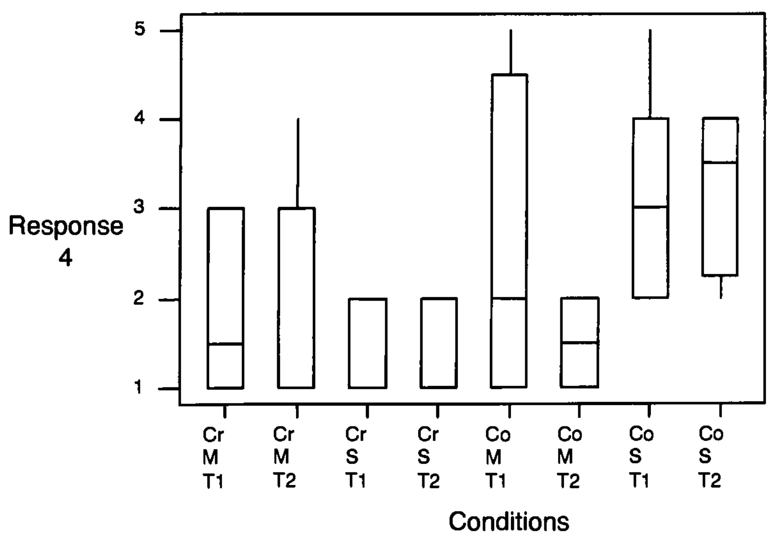
Control: Trial = 1
Rows: Method
Columns: Delivery

	M	S	All
Cr	1.8333	1.6667	1.7778
	3.0000	2.0000	--
	2.0000	2.0000	
	3.0000	1.0000	
	1.0000		
	1.0000		
	1.0000		
Co	2.5000	3.0000	2.7778
	1.0000	2.0000	--
	1.0000	2.0000	
	3.0000	3.0000	
	5.0000	3.0000	
		5.0000	
All	2.1000	2.5000	2.2778
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	1.8571	1.3333	1.7000
	3.0000	2.0000	--
	1.0000	1.0000	
	2.0000	1.0000	
	1.0000		
	4.0000		
	1.0000		
	1.0000		
Co	1.5000	3.2500	2.6667
	1.0000	3.0000	--
	2.0000	4.0000	
		4.0000	
		2.0000	
All	1.7778	2.4286	2.0625
	--	--	--

Boxplot of Response 4 vs. Method, Delivery, Trial:
(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 5. Power Down

Response variable: Response 6

Tabulated Statistics: Response 6 vs. Method, Delivery, Trial

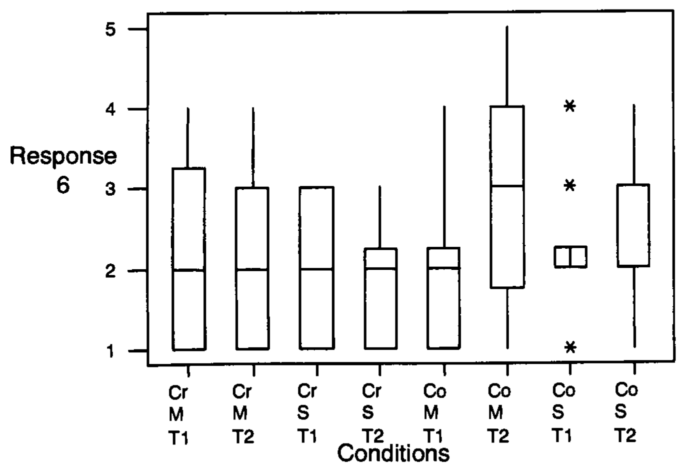
Control: Trial = 1
Rows: Method
Columns: Delivery

	M	S	All
Cr	2.3000	1.9000	2.1000
	4.0000	3.0000	--
	3.0000	2.0000	
	2.0000	3.0000	
	3.0000	3.0000	
	2.0000	1.0000	
	4.0000	1.0000	
	1.0000	1.0000	
	1.0000	2.0000	
	1.0000	1.0000	
	2.0000	2.0000	
Co	2.0000	2.2000	2.1000
	4.0000	3.0000	--
	1.0000	2.0000	
	2.0000	1.0000	
	1.0000	2.0000	
	1.0000	2.0000	
	2.0000	2.0000	
	2.0000	2.0000	
	2.0000	4.0000	
	2.0000	2.0000	
	3.0000	2.0000	
All	2.1500	2.0500	2.1000
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	2.1000	1.9000	2.0000
	3.0000	2.0000	--
	2.0000	1.0000	
	3.0000	3.0000	
	2.0000	3.0000	
	2.0000	1.0000	
	4.0000	2.0000	
	1.0000	2.0000	
	1.0000	2.0000	
	1.0000	1.0000	
	2.0000	2.0000	
Co	2.8000	2.7000	2.7500
	3.0000	3.0000	--
	1.0000	3.0000	
	2.0000	1.0000	
	1.0000	3.0000	
	4.0000	2.0000	
	3.0000	3.0000	
	3.0000	3.0000	
	4.0000	4.0000	
	2.0000	2.0000	
	5.0000	3.0000	
All	2.4500	2.3000	2.3750
	--	--	--

Boxplot of Response 6 vs. Method, Delivery, Trial:
(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 6. Overall Impression of Interface
Response variable: Response 1

Tabulated Statistics: Response 1 vs. Method, Delivery, Trial

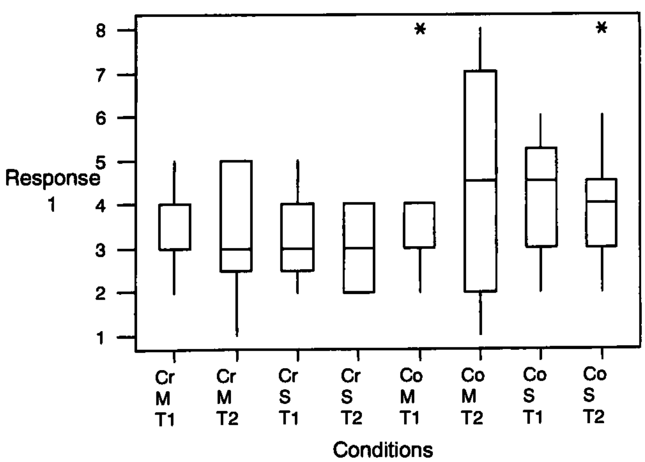
```
Control: Trial = 1
Rows: Method
Columns: Delivery
```

	M	S	All
Cr	3.4000	3.2222	3.3158
	5.0000	3.0000	--
	4.0000	4.0000	
	3.0000	4.0000	
	3.0000	5.0000	
	4.0000	2.0000	
	3.0000	3.0000	
	3.0000	3.0000	
	3.0000	2.0000	
	2.0000	3.0000	
	4.0000		
Co	3.7000	4.2000	3.9500
	8.0000	5.0000	--
	2.0000	6.0000	
	4.0000	4.0000	
	3.0000	5.0000	
	3.0000	3.0000	
	3.0000	6.0000	
	3.0000	3.0000	
	4.0000	5.0000	
	4.0000	2.0000	
	3.0000	3.0000	
All	3.5500	3.7368	3.6410
	--	--	--

```
Control: Trial = 2
Rows: Method
Columns: Delivery
```

	M	S	All
Cr	3.4444	2.9000	3.1579
	5.0000	2.0000	--
	5.0000	3.0000	
	3.0000	4.0000	
	4.0000	4.0000	
	5.0000	2.0000	
	3.0000	2.0000	
	2.0000	3.0000	
	1.0000	3.0000	
	3.0000	4.0000	
		2.0000	
Co	4.5000	4.2000	4.3500
	7.0000	3.0000	--
	1.0000	6.0000	
	6.0000	3.0000	
	2.0000	4.0000	
	4.0000	4.0000	
	3.0000	8.0000	
	2.0000	4.0000	
	7.0000	4.0000	
	8.0000	4.0000	
	5.0000	2.0000	
All	4.0000	3.5500	3.7692
	--	--	--

Boxplot of Response 1 vs. Method, Delivery, Trial:
(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 6. Overall Impression of Interface

Response variable: Response 2

Tabulated Statistics: Response 2 vs. Method, Delivery, Trial

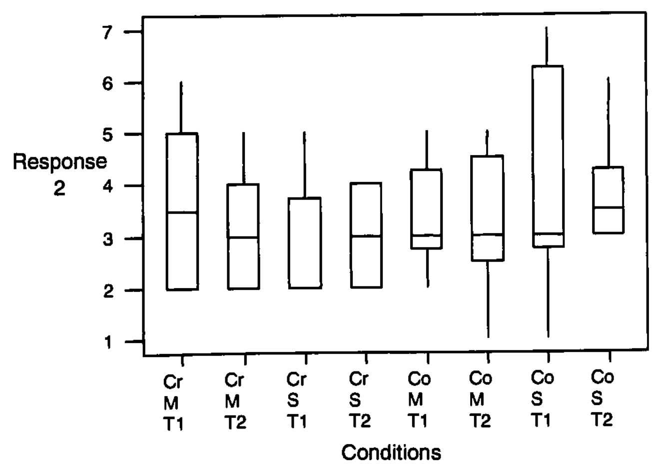
Control: Trial = 1
Rows: Method
Columns: Delivery

	M	S	All
Cr	3.6000	2.7500	3.2222
	6.0000	2.0000	--
	5.0000	2.0000	
	2.0000	3.0000	
	4.0000	5.0000	
	5.0000	2.0000	
	4.0000	4.0000	
	2.0000	2.0000	
	3.0000	2.0000	
	2.0000		
	3.0000		
Co	3.3000	3.9000	3.6000
	2.0000	3.0000	--
	3.0000	7.0000	
	5.0000	3.0000	
	3.0000	3.0000	
	2.0000	4.0000	
	4.0000	6.0000	
	3.0000	2.0000	
	3.0000	7.0000	
	5.0000	1.0000	
	3.0000	3.0000	
All	3.4500	3.3889	3.4211
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	3.1111	3.0000	3.0526
	5.0000	3.0000	--
	4.0000	2.0000	
	3.0000	4.0000	
	3.0000	4.0000	
	4.0000	2.0000	
	2.0000	3.0000	
	2.0000	3.0000	
	2.0000	4.0000	
	3.0000	3.0000	
		2.0000	
Co	3.3333	3.8000	3.5789
	2.0000	3.0000	--
	1.0000	6.0000	
	5.0000	3.0000	
	3.0000	3.0000	
	3.0000	4.0000	
	4.0000	4.0000	
	3.0000	3.0000	
	4.0000	5.0000	
	5.0000	4.0000	
		3.0000	
All	3.2222	3.4000	3.3158
	--	--	--

Boxplot of Response 2 vs. Method, Delivery, Trial:
(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 6. Overall Impression of Interface

Response variable: Response 3

Tabulated Statistics: Response 3 vs. Method, Delivery, Trial

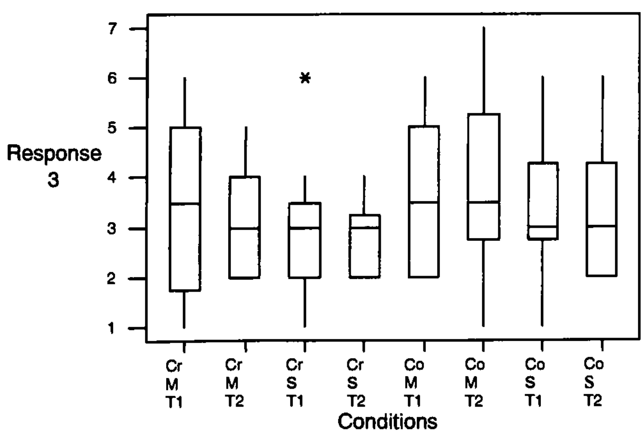
Control: Trial = 1
Rows: Method
Columns: Delivery

	M	S	All
Cr	3.5000	3.0000	3.2632
	6.0000	3.0000	--
	5.0000	2.0000	
	2.0000	4.0000	
	5.0000	6.0000	
	5.0000	1.0000	
	4.0000	3.0000	
	1.0000	3.0000	
	3.0000	2.0000	
	1.0000	3.0000	
	3.0000		
Co	3.6000	3.4000	3.5000
	2.0000	3.0000	--
	2.0000	6.0000	
	5.0000	3.0000	
	4.0000	3.0000	
	2.0000	4.0000	
	3.0000	5.0000	
	4.0000	3.0000	
	3.0000	4.0000	
	5.0000	1.0000	
	6.0000	2.0000	
All	3.5500	3.2105	3.3846
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	3.1111	2.8000	2.9474
	5.0000	2.0000	--
	4.0000	2.0000	
	3.0000	3.0000	
	4.0000	4.0000	
	3.0000	2.0000	
	2.0000	3.0000	
	2.0000	3.0000	
	2.0000	4.0000	
	3.0000	3.0000	
		2.0000	
Co	3.8000	3.3000	3.5500
	2.0000	2.0000	--
	1.0000	4.0000	
	6.0000	2.0000	
	3.0000	3.0000	
	4.0000	3.0000	
	3.0000	5.0000	
	3.0000	2.0000	
	4.0000	6.0000	
	7.0000	3.0000	
	5.0000	3.0000	
All	3.4737	3.0500	3.2564
	--	--	--

Boxplot of Response 3 vs. Method, Delivery, Trial:
(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 6. Overall Impression of Interface
Response variable: Response 4

Tabulated Statistics: Response 4 vs. Method, Delivery, Trial

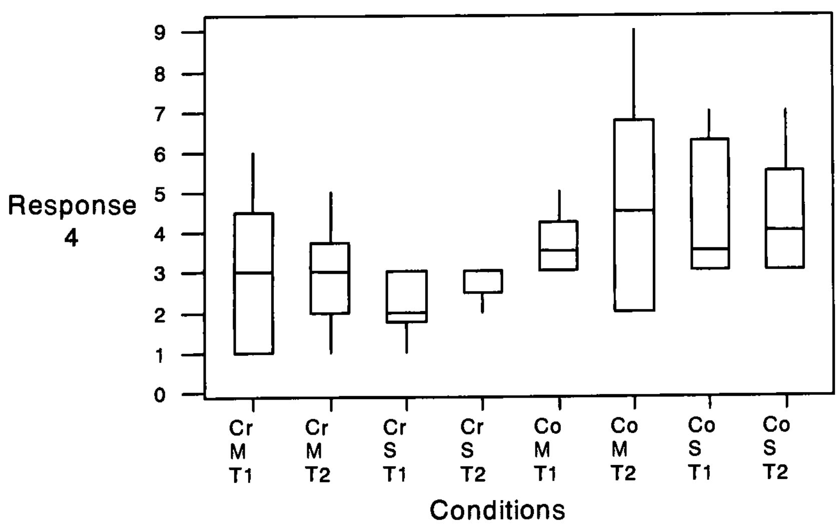
Control: Trial = 1
Rows: Method
Columns: Delivery

	M	S	All
Cr	2.8889	2.1667	2.6000
	4.0000	2.0000	--
	6.0000	2.0000	
	2.0000	3.0000	
	3.0000	2.0000	
	5.0000	3.0000	
	3.0000	1.0000	
	1.0000		
	1.0000		
	1.0000		
Co	3.6667	4.3333	4.0000
	3.0000	4.0000	--
	5.0000	7.0000	
	3.0000	3.0000	
	4.0000	3.0000	
	3.0000	6.0000	
	4.0000	3.0000	
All	3.2000	3.2500	3.2222
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	2.8750	2.7778	2.8235
	4.0000	3.0000	--
	5.0000	2.0000	
	2.0000	3.0000	
	3.0000	3.0000	
	3.0000	3.0000	
	1.0000	3.0000	
	2.0000	3.0000	
	3.0000	2.0000	
		3.0000	
Co	4.6667	4.2222	4.4000
	9.0000	4.0000	--
	2.0000	4.0000	
	4.0000	3.0000	
	2.0000	3.0000	
	5.0000	7.0000	
	6.0000	3.0000	
		6.0000	
		5.0000	
		3.0000	
All	3.6429	3.5000	3.5625
	--	--	--

Boxplot of Response 4 vs. Method, Delivery, Trial:
(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 6. Overall Impression of Interface
Response variable: Response 5

Tabulated Statistics: Response 5 vs. Method, Delivery, Trial

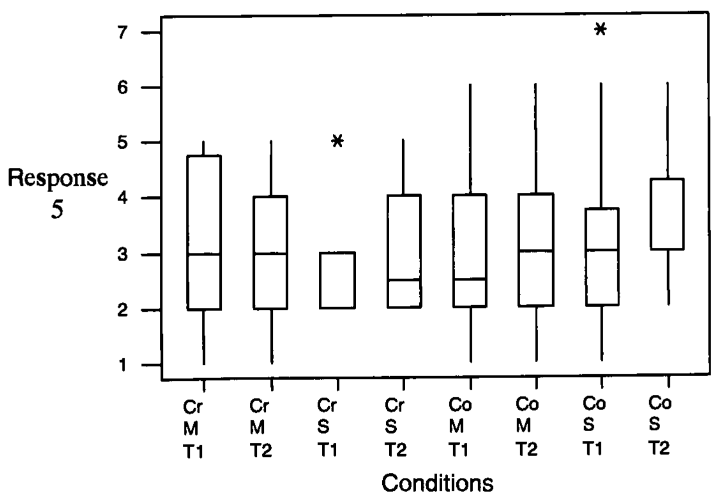
Control: Trial = 1
Rows: Method
Columns: Delivery

	M	S	All
Cr	3.1250	2.6667	2.8824
	5.0000	2.0000	--
	4.0000	2.0000	
	2.0000	3.0000	
	4.0000	5.0000	
	5.0000	2.0000	
	2.0000	3.0000	
	2.0000	2.0000	
	1.0000	3.0000	
		2.0000	
Co	2.9000	3.2000	3.0500
	1.0000	2.0000	--
	2.0000	6.0000	
	4.0000	2.0000	
	6.0000	3.0000	
	2.0000	2.0000	
	2.0000	7.0000	
	3.0000	3.0000	
	3.0000	3.0000	
	4.0000	1.0000	
	2.0000	3.0000	
All	3.0000	2.9474	2.9730
	--	--	--

Control: Trial 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	2.8889	2.9000	2.8947
	5.0000	2.0000	--
	5.0000	2.0000	
	3.0000	4.0000	
	2.0000	5.0000	
	3.0000	2.0000	
	2.0000	2.0000	
	2.0000	3.0000	
	1.0000	4.0000	
	3.0000	2.0000	
		3.0000	
Co	3.0000	3.6000	3.3158
	2.0000	2.0000	--
	1.0000	4.0000	
	4.0000	4.0000	
	3.0000	3.0000	
	2.0000	5.0000	
	2.0000	6.0000	
	3.0000	3.0000	
	6.0000	3.0000	
	4.0000	3.0000	
		3.0000	
All	2.9444	3.2500	3.1053
	--	--	--

Boxplot of Response 5 vs. Method, Delivery, Trial:
(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)



Task 6. Overall Impression of Interface
Response variable: Response 6

Tabulated Statistics: Response 6 vs. Method, Delivery, Trial

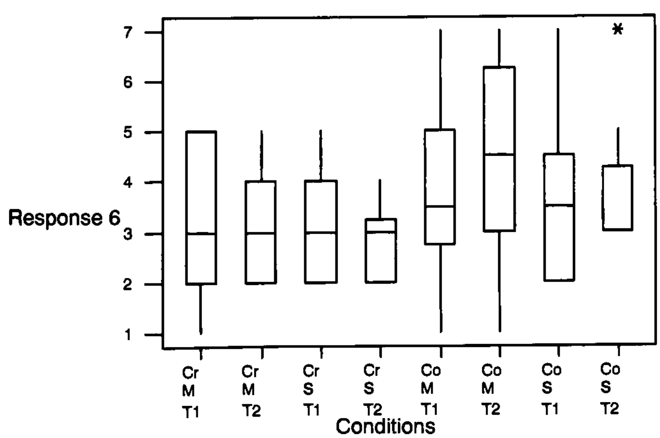
Control: Trial = 1
Rows: Method
Columns: Delivery

	M	S	All
Cr	3.3000	3.1111	3.2105
	5.0000	2.0000	--
	4.0000	4.0000	
	2.0000	4.0000	
	3.0000	5.0000	
	5.0000	2.0000	
	5.0000	3.0000	
	2.0000	3.0000	
	3.0000	3.0000	
	1.0000	2.0000	
	3.0000		
Co	3.7000	3.7000	3.7000
	7.0000	4.0000	--
	1.0000	6.0000	
	5.0000	3.0000	
	3.0000	4.0000	
	2.0000	3.0000	
	3.0000	7.0000	
	4.0000	2.0000	
	3.0000	4.0000	
	5.0000	2.0000	
	4.0000	2.0000	
All	3.5000	3.4211	3.4615
	--	--	--

Control: Trial = 2
Rows: Method
Columns: Delivery

	M	S	All
Cr	3.1111	2.8000	2.9474
	5.0000	2.0000	--
	5.0000	3.0000	
	3.0000	4.0000	
	3.0000	4.0000	
	3.0000	2.0000	
	2.0000	2.0000	
	2.0000	3.0000	
	2.0000	3.0000	
	3.0000	3.0000	
		2.0000	
Co	4.4000	3.7000	4.0500
	7.0000	3.0000	--
	1.0000	5.0000	
	5.0000	3.0000	
	3.0000	3.0000	
	4.0000	3.0000	
	3.0000	7.0000	
	3.0000	3.0000	
	6.0000	4.0000	
	7.0000	3.0000	
	5.0000	3.0000	
All	3.7895	3.2500	3.5128
	--	--	--

Boxplot of Response 6 vs. Method, Delivery, Trial:
(Cr=criteria, Co=Conventional, m=multiple, s=single, T1=trial 1, T2=trial 2)

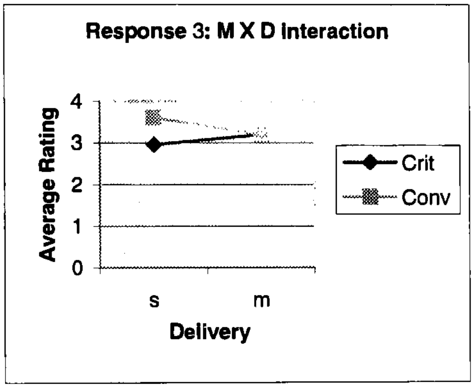


Appendix J: Subjective Data Analysis Output
ANOVA Results

Summary of Significant Power up and Zero Return ANOVA Results

Significance Level:	<= 0.01	<=0.05

Powerup Zero Return Metric	Method (M)		Delivery (D)		Trial (R)		M X D		M X R		D X R		M X D X R	
	F	p	F	p	F	p	F	p	F	p	F	p	F	p
Response 3: Ease of understanding screen displays & finding correct soft key or data display	0.400	0.533	2.730	0.108	0.030	0.866	5.140	0.030	0.000	0.966	0.070	0.800	0.220	0.642
							<=0.05							



Task 1. Power Up and Zero Return

Response variable: Response 3

```
 Analysis of Variance for Response 3, using Adjusted SS for Tests

Source                      DF     Seq SS     Adj SS     Adj MS       F       P
Method                       1      1.141      0.934      0.934    0.40   0.533 x
Delivery                     1      4.477      6.411      6.411    2.73   0.108 x
Run                          1      1.110      0.043      0.043    0.03   0.866
Method*Delivery              1     13.980     12.070     12.070    5.14   0.030 x
Method*Run                   1      0.386      0.003      0.003    0.00   0.966
Delivery*Run                 1      0.038      0.096      0.096    0.07   0.800
Method*Delivery*Run          1      0.567      0.323      0.323    0.22   0.642
Subject(Method Delivery)    29     70.408     70.408      2.428    1.66   0.107
Error                       23     33.543     33.543      1.458
Total                       59    125.650

x Not an exact F-test.

Unusual Observations for Response 3

Obs  Response       Fit    StDev Fit   Residual    St Resid
 13   2.00000   2.00000      1.20764    0.00000          * X
 17   1.00000   1.00000      1.20764   -0.00000          * X
 27   1.00000   1.00000      1.20764   -0.00000          * X
 29   2.00000   2.00000      1.20764   -0.00000          * X
 51   2.00000   2.00000      1.20764   -0.00000          * X
 75   3.00000   3.00000      1.20764    0.00000          * X

X denotes an observation whose X value gives it large influence.
```

Summary of Significant Activate Stored Program ANOVA Results

Activate Stored Program Metric	Method (M) F	Method (M) p	Delivery (D) F	Delivery (D) p	Trial (R) F	Trial (R) p	M X D F	M X D p	M X R F	M X R p	D X R F	D X R p	M X D X R F	M X D X R p
Response 1: Ease of finding correct control & understanding labeling	1.080	0.307	0.200	0.659	28.470	0.000	0.020	0.883	2.120	0.154	0.240	0.631	0.240	0.631
					Trial 1 < Trial 2									
Response 2: Ease of understanding menu structure	1.520	0.225	0.150	0.704	6.140	0.019	0.530	0.472	0.100	0.755	0.010	0.905	0.040	0.851
					Trial 1 < Trial 2									
Response 3: Ease of understanding screen displays & finding correct soft key or data display	1.260	0.269	0.670	0.417	4.610	0.039	0.070	0.800	0.050	0.818	0.050	0.818	2.460	0.127
					Trial 1 < Trial 2									
Response 5: Ease of using multi-function keys	1.110	0.300	0.170	0.684	6.000	0.022	0.010	0.943	0.690	0.415	0.690	0.415	0.020	0.888
					Trial 1 < Trial 2									
Response 6: Overall ease of operation	1.520	0.226	0.170	0.684	16.300	0.000	0.060	0.807	0.230	0.631	0.650	0.425	0.030	0.873
					Trial 1 < Trial 2									

Task 2. Activate Stored Program

Response variable: Response 1

Analysis of Variance for Response 1, using Adjusted SS for Tests

```
Source                      DF      Seq SS      Adj SS      Adj MS       F       P
Method                       1      2.4500      2.4500      2.4500    1.08   0.307
Delivery                     1      0.4500      0.4500      0.4500    0.20   0.659
Run                          1     24.2000     24.2000     24.2000   28.47   0.000
Method*Delivery              1      0.0500      0.0500      0.0500    0.02   0.883
Method*Run                   1      1.8000      1.8000      1.8000    2.12   0.154
Delivery*Run                 1      0.2000      0.2000      0.2000    0.24   0.631
Method*Delivery*Run          1      0.2000      0.2000      0.2000    0.24   0.631
Subject(Method Delivery)    36     82.0000     82.0000      2.2778    2.68   0.002
Error                       36     30.6000     30.6000      0.8500
Total                       79    141.9500

Unusual Observations for Response 1

Obs   Response        Fit   StDev Fit   Residual    St Resid
  3    2.00000    3.30000     0.68374   -1.30000      -2.10R
  4    6.00000    4.70000     0.68374    1.30000       2.10R
 25    3.00000    4.80000     0.68374   -1.80000      -2.91R
 26    8.00000    6.20000     0.68374    1.80000       2.91R

R denotes an observation with a large standardized residual.
```

Task 2. Activate Stored Program

Response variable: Response 2

Analysis of Variance for Response 2, using Adjusted SS for Tests

```
Source                      DF      Seq SS      Adj SS      Adj MS       F       P
Method                       1      3.9054      3.3482      3.3482    1.52   0.225 x
Delivery                     1      0.1779      0.3213      0.3213    0.15   0.704 x
Run                          1      3.2298      3.5224      3.5224    6.14   0.019
Method*Delivery              1      1.0505      1.1619      1.1619    0.53   0.472 x
Method*Run                   1      0.0053      0.0566      0.0566    0.10   0.755
Delivery*Run                 1      0.0660      0.0083      0.0083    0.01   0.905
Method*Delivery*Run          1      0.0486      0.0207      0.0207    0.04   0.851
Subject(Method Delivery)    34     76.2514     76.2514      2.2427    3.91   0.000
Error                       32     18.3597     18.3597      0.5737
Total                       73    103.0946

x Not an exact F-test.
```

Unusual Observations for Response 2

Obs	Response	Fit	StDev Fit	Residual	St Resid
25	4.00000	5.27778	0.56458	-1.27778	-2.53R
26	7.00000	5.72222	0.56458	1.27778	2.53R
32	2.00000	2.00000	0.75746	0.00000	* X
58	3.00000	3.00000	0.75746	0.00000	* X

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large influence.

Task 2. Activate Stored Program
Response variable: Response 3

Analysis of Variance for Response 3, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Method	1	2.3049	2.4631	2.4631	1.26	0.269 x
Delivery	1	1.3464	1.3174	1.3174	0.67	0.417 x
Run	1	4.8911	3.8028	3.8028	4.61	0.039
Method*Delivery	1	0.3201	0.1276	0.1276	0.07	0.800 x
Method*Run	1	0.0553	0.0444	0.0444	0.05	0.818
Delivery*Run	1	0.0448	0.0444	0.0444	0.05	0.818
Method*Delivery*Run	1	1.7269	2.0250	2.0250	2.46	0.127
Subject(Method Delivery)	35	70.3222	70.3222	2.0092	2.44	0.006
Error	32	26.3750	26.3750	0.8242		
Total	74	107.3867				

x Not an exact F-test.

Unusual Observations for Response 3

Obs	Response	Fit	StDev Fit	Residual	St Resid
25	4.00000	5.93750	0.68090	-1.93750	-3.23R
26	8.00000	6.06250	0.68090	1.93750	3.23R
32	3.00000	3.00000	0.90786	-0.00000	* X
40	4.00000	4.00000	0.90786	0.00000	* X
54	3.00000	3.00000	0.90786	-0.00000	* X

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large influence.

Task 2. Activate Stored Program

Response variable: Response 5

Analysis of Variance for Response 5, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Method	1	2.9697	1.9542	1.9542	1.11	0.300 x
Delivery	1	0.0891	0.2975	0.2975	0.17	0.684 x
Run	1	7.4516	4.2169	4.2169	6.00	0.022
Method*Delivery	1	0.6920	0.0092	0.0092	0.01	0.943 x
Method*Run	1	0.4119	0.4842	0.4842	0.69	0.415
Delivery*Run	1	0.0694	0.4842	0.4842	0.69	0.415
Method*Delivery*Run	1	0.0107	0.0141	0.0141	0.02	0.888
Subject(Method Delivery)	33	61.9978	61.9978	1.8787	2.67	0.007
Error	25	17.5804	17.5804	0.7032		
Total	65	91.2727				

x Not an exact F-test.

Unusual Observations for Response 5

Obs	Response	Fit	StDev Fit	Residual	St Resid
5	3.00000	3.00000	0.83858	0.00000	* X
17	1.00000	1.00000	0.83858	-0.00000	* X
19	2.00000	2.00000	0.83858	0.00000	* X
23	3.00000	1.71429	0.63391	1.28571	2.34R
24	1.00000	2.28571	0.63391	-1.28571	-2.34R
28	4.00000	4.00000	0.83858	0.00000	* X
35	3.00000	3.00000	0.83858	0.00000	* X
39	1.00000	2.21429	0.63391	-1.21429	-2.21R
40	4.00000	2.78571	0.63391	1.21429	2.21R
46	4.00000	4.00000	0.83858	0.00000	* X
60	3.00000	3.00000	0.83858	-0.00000	* X
75	2.00000	2.00000	0.83858	-0.00000	* X

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large influence.

Task 2. Activate Stored Program
Response variable: Response 6

Analysis of Variance for Response 6, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Method	1	2.8125	2.8125	2.8125	1.52	0.226
Delivery	1	0.3125	0.3125	0.3125	0.17	0.684
Run	1	7.8125	7.8125	7.8125	16.30	0.000
Method*Delivery	1	0.1125	0.1125	0.1125	0.06	0.807
Method*Run	1	0.1125	0.1125	0.1125	0.23	0.631
Delivery*Run	1	0.3125	0.3125	0.3125	0.65	0.425
Method*Delivery*Run	1	0.0125	0.0125	0.0125	0.03	0.873
Subject(Method Delivery)	36	66.6500	66.6500	1.8514	3.86	0.000
Error	36	17.2500	17.2500	0.4792		
Total	79	95.3875				

Unusual Observations for Response 6

Obs	Response	Fit	StDev Fit	Residual	St Resid
25	4.00000	5.30000	0.51336	-1.30000	-2.80R
26	7.00000	5.70000	0.51336	1.30000	2.80R

R denotes an observation with a large standardized residual.

Summary of Significant Collet Open/Close ANOVA Results

Significance Level: <= 0.01 | <=0.05

Collet Open/Close	Method (M)		Delivery (D)		Trial (R)		M X D		M X R		D X R		M X D X R	
Metric	F	p	F	p	F	p	F	p	F	p	F	p	F	p
Response 4: Ease of making corrections or error recovery	**5.370**	**0.037**	0.460	0.510	1.420	0.268	2.550	0.133	0.260	0.623	0.260	0.623	1.420	0.268
	Crit < Conv													
Response 6: Overall ease of operation	0.000	1.000	0.290	0.593	**4.350**	**0.044**	0.030	0.858	1.090	0.304	0.070	0.796	0.610	0.439
					Trial 1 < Trial 2									

Crit < Conv indicates Criterion subjects rated tasks as easier
Conv < Crit indicates Conventional subjects rated tasks as easier

Task 3. Collet Open/Close

Response variable: Response 4

Analysis of Variance for Response 4, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P	
Method	1	14.2287	12.3410	12.3410	5.37	0.037	x
Delivery	1	0.7749	1.0510	1.0510	0.46	0.510	x
Run	1	0.2631	0.6391	0.6391	1.42	0.268	
Method*Delivery	1	10.7531	5.8537	5.8537	2.55	0.133	x
Method*Run	1	1.6882	0.1174	0.1174	0.26	0.623	
Delivery*Run	1	0.0049	0.1174	0.1174	0.26	0.623	
Method*Delivery*Run	1	0.0027	0.6391	0.6391	1.42	0.268	
Subject(Method Delivery)	13	33.6500	33.6500	2.5885	5.75	0.009	
Error	8	3.6000	3.6000	0.4500			
Total	28	64.9655					

x Not an exact F-test.

Unusual Observations for Response 4

Obs	Response	Fit	StDev Fit	Residual	St Resid
1	4.00000	4.00000	0.67082	-0.00000	* X
33	4.00000	4.00000	0.67082	-0.00000	* X
60	2.00000	2.00000	0.67082	0.00000	* X
69	1.00000	1.00000	0.67082	-0.00000	* X
72	4.00000	4.00000	0.67082	0.00000	* X

X denotes an observation whose X value gives it large influence.

Task 3. Collet Open/Close

Response Variable: Response 6

Analysis of Variance for Response 6, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Method	1	0.0000	0.0000	0.0000	0.00	1.000
Delivery	1	0.4500	0.4500	0.4500	0.29	0.593
Run	1	3.2000	3.2000	3.2000	4.35	0.044
Method*Delivery	1	0.0500	0.0500	0.0500	0.03	0.858
Method*Run	1	0.8000	0.8000	0.8000	1.09	0.304
Delivery*Run	1	0.0500	0.0500	0.0500	0.07	0.796
Method*Delivery*Run	1	0.4500	0.4500	0.4500	0.61	0.439
Subject(Method Delivery)	36	55.7000	55.7000	1.5472	2.10	0.014
Error	36	26.5000	26.5000	0.7361		
Total	79	87.2000				

Unusual Observations for Response 6

Obs	Response	Fit	StDev Fit	Residual	St Resid
29	1.00000	2.25000	0.63629	-1.25000	-2.17R
30	4.00000	2.75000	0.63629	1.25000	2.17R
37	3.00000	1.75000	0.63629	1.25000	2.17R
38	1.00000	2.25000	0.63629	-1.25000	-2.17R
45	5.00000	3.50000	0.63629	1.50000	2.61R
46	2.00000	3.50000	0.63629	-1.50000	-2.61R

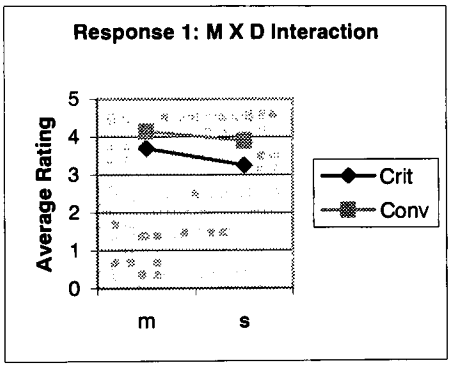
R denotes an observation with a large standardized residual.

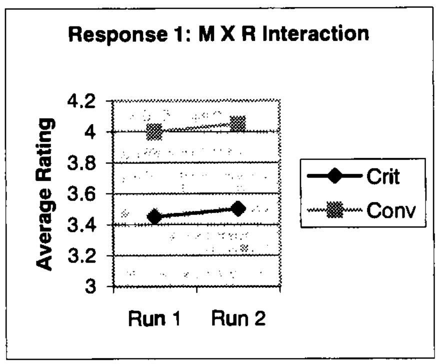
Summary of Significant Make First Part ANOVA Results

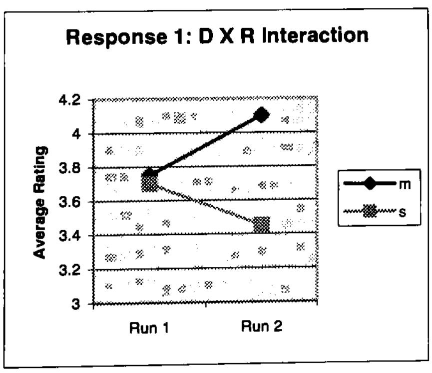
Significance Level: <= 0.01 | <=0.05

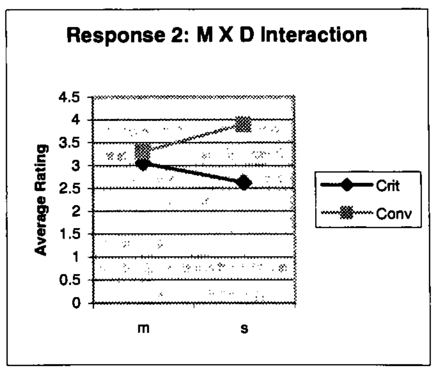
Make First Part Metric	Method (M) F	Method (M) p	Delivery (D) F	Delivery (D) p	Run (R) F	Run (R) p	M X D F	M X D p	M X R F	M X R p	D X R F	D X R p	M X D X R F	M X D X R p
Response 1: Ease of finding correct control & understanding labeling	1.380	0.247	0.560	0.459	0.040	0.839	0.050	0.832	0.000	1.000	1.500	0.228	5.050	0.031
													<=0.05	
Response 2: Ease of understanding menu structure	4.670	0.037	0.020	0.879	6.320	0.017	2.190	0.147	1.100	0.301	0.540	0.469	5.100	0.030
	Crit < Conv				Run 1 < Run 2								<=0.05	
Response 3: Ease of understanding screen displays & finding correct soft key or data display	4.180	0.048	0.360	0.551	7.070	0.012	0.710	0.405	2.860	0.099	1.460	0.235	0.530	0.473
	Crit < Conv				Run 1 < Run 2									
Response 4: Ease of making corrections or error recovery	15.420	0.000	0.390	0.538	0.520	0.483	0.290	0.592	5.200	0.042	1.120	0.311	1.640	0.225
	Crit < Conv								<=0.05					
Response 6: Overall ease of operation	5.160	0.029	0.340	0.563	1.520	0.226	0.110	0.747	0.010	0.911	2.120	0.154	1.020	0.320
	Crit < Conv													

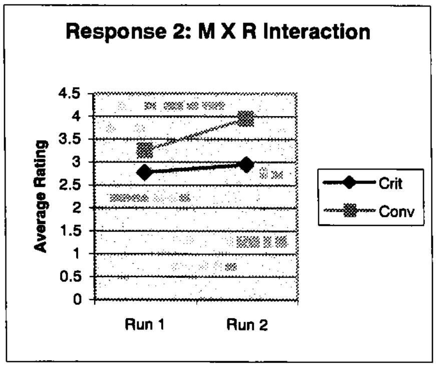
Crit < Conv indicates Criterion subjects rated tasks as easier
Conv < Crit indicates Conventional subjects rated tasks easier

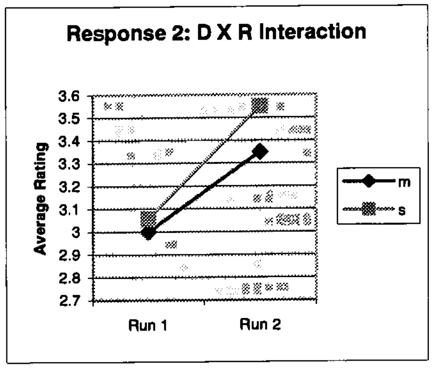


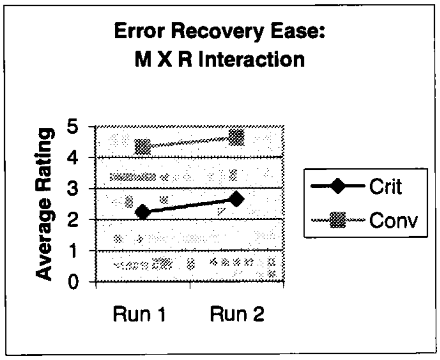












Task 4. Make First Part

Response variable: Response 1

Analysis of Variance for Response 1, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Method	1	6.050	6.050	6.050	1.38	0.247
Delivery	1	2.450	2.450	2.450	0.56	0.459
Run	1	0.050	0.050	0.050	0.04	0.839
Method*Delivery	1	0.200	0.200	0.200	0.05	0.832
Method*Run	1	0.000	0.000	0.000	0.00	1.000
Delivery*Run	1	1.800	1.800	1.800	1.50	0.228
Method*Delivery*Run	1	6.050	6.050	6.050	5.05	0.031
Subject(Method Delivery)	36	157.300	157.300	4.369	3.65	0.000
Error	36	43.100	43.100	1.197		
Total	79	217.000				

Unusual Observations for Response 1

Obs	Response	Fit	StDev Fit	Residual	St Resid
35	3.00000	4.55000	0.81146	-1.55000	-2.11R
36	7.00000	5.45000	0.81146	1.55000	2.11R
55	2.00000	3.85000	0.81146	-1.85000	-2.52R
56	6.00000	4.15000	0.81146	1.85000	2.52R

R denotes an observation with a large standardized residual.

Task 4. Make First Part

Response variable: Response 2

Analysis of Variance for Response 2, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P	
Method	1	10.4297	11.8596	11.8596	4.67	0.037	x
Delivery	1	0.2881	0.0596	0.0596	0.02	0.879	x
Run	1	3.7721	4.5890	4.5890	6.32	0.017	
Method*Delivery	1	4.9448	5.5654	5.5654	2.19	0.147	x
Method*Run	1	1.2430	0.8007	0.8007	1.10	0.301	
Delivery*Run	1	0.1941	0.3890	0.3890	0.54	0.469	
Method*Delivery*Run	1	3.3000	3.7066	3.7066	5.10	0.030	
Subject(Method Delivery)	36	93.5125	93.5125	2.5976	3.58	0.000	
Error	34	24.6875	24.6875	0.7261			
Total	77	142.3718					

x Not an exact F-test.

Unusual Observations for Response 2

Obs	Response	Fit	StDev Fit	Residual	St Resid
1	5.00000	3.80000	0.63195	1.20000	2.10R
2	3.00000	4.20000	0.63195	-1.20000	-2.10R
13	2.00000	3.30000	0.63195	-1.30000	-2.27R
14	5.00000	3.70000	0.63195	1.30000	2.27R
46	3.00000	3.00000	0.85212	0.00000	* X
58	2.00000	2.00000	0.85212	-0.00000	* X

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large influence.

Task 4. Make First Part

Response variable: Response 3

Analysis of Variance for Response 3, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Method	1	14.4500	14.4500	14.4500	4.18	0.048
Delivery	1	1.2500	1.2500	1.2500	0.36	0.551
Run	1	6.0500	6.0500	6.0500	7.07	0.012
Method*Delivery	1	2.4500	2.4500	2.4500	0.71	0.405
Method*Run	1	2.4500	2.4500	2.4500	2.86	0.099
Delivery*Run	1	1.2500	1.2500	1.2500	1.46	0.235
Method*Delivery*Run	1	0.4500	0.4500	0.4500	0.53	0.473
Subject(Method Delivery)	36	124.4000	124.4000	3.4556	4.04	0.000
Error	36	30.8000	30.8000	0.8556		
Total	79	183.5500				

Unusual Observations for Response 3

Obs	Response	Fit	StDev Fit	Residual	St Resid
3	7.00000	5.25000	0.68597	1.75000	2.82R
4	4.00000	5.75000	0.68597	-1.75000	-2.82R
9	2.00000	3.25000	0.68597	-1.25000	-2.01R
10	5.00000	3.75000	0.68597	1.25000	2.01R
17	1.00000	2.75000	0.68597	-1.75000	-2.82R
18	5.00000	3.25000	0.68597	1.75000	2.82R
25	4.00000	5.35000	0.68597	-1.35000	-2.18R
26	8.00000	6.65000	0.68597	1.35000	2.18R

R denotes an observation with a large standardized residual.

Task 4. Make First Part

Response variable: Response 4

Analysis of Variance for Response, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P	
Method	1	48.5461	40.9538	40.9538	15.42	0.000	x
Delivery	1	0.0388	1.0398	1.0398	0.39	0.536	x
Run	1	1.5314	0.5030	0.5030	0.52	0.483	
Method*Delivery	1	0.5558	0.7806	0.7806	0.29	0.592	x
Method*Run	1	0.0125	5.0030	5.0030	5.20	0.042	
Delivery*Run	1	3.3426	1.0744	1.0744	1.12	0.311	
Method*Delivery*Run	1	0.4642	1.5744	1.5744	1.64	0.225	
Subject(Method Delivery)	27	78.1798	78.1798	2.8955	3.01	0.024	
Error	12	11.5417	11.5417	0.9618			
Total	46	144.2128					

x Not an exact F-test.

Unusual Observations for Response

Obs	Response	Fit	StDev Fit	Residual	St Resid
5	3.00000	3.00000	0.98072	-0.00000	* X
10	3.00000	3.00000	0.98072	-0.00000	* X
15	3.00000	4.62500	0.77532	-1.62500	-2.71R
16	6.00000	4.37500	0.77532	1.62500	2.71R
18	5.00000	5.00000	0.98072	0.00000	* X
20	3.00000	3.00000	0.98072	0.00000	* X
22	9.00000	9.00000	0.98072	0.00000	* X
27	2.00000	2.00000	0.98072	0.00000	* X
33	4.00000	4.00000	0.98072	-0.00000	* X
36	6.00000	6.00000	0.98072	-0.00000	* X
45	3.00000	3.00000	0.98072	0.00000	* X
48	2.00000	2.00000	0.98072	0.00000	* X
54	2.00000	2.00000	0.98072	0.00000	* X
58	2.00000	2.00000	0.98072	0.00000	* X
71	4.00000	4.00000	0.98072	0.00000	* X
75	1.00000	1.00000	0.98072	0.00000	* X
80	4.00000	4.00000	0.98072	0.00000	* X

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large influence.

Task 4. Make First Part

Response variable: Response 6

Analysis of Variance for Response, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Method	1	15.3125	15.3125	15.3125	5.16	0.029
Delivery	1	1.0125	1.0125	1.0125	0.34	0.563
Run	1	1.5125	1.5125	1.5125	1.52	0.226
Method*Delivery	1	0.3125	0.3125	0.3125	0.11	0.747
Method*Run	1	0.0125	0.0125	0.0125	0.01	0.911
Delivery*Run	1	2.1125	2.1125	2.1125	2.12	0.154
Method*Delivery*Run	1	1.0125	1.0125	1.0125	1.02	0.320
Subject(Method Delivery)	36	106.8500	106.8500	2.9681	2.98	0.001
Error	36	35.8500	35.8500	0.9958		
Total	79	163.9875				

Unusual Observations for Response

Obs	Response	Fit	StDev Fit	Residual	St Resid
3	7.00000	5.65000	0.74007	1.35000	2.02R
4	4.00000	5.35000	0.74007	-1.35000	-2.02R
11	9.00000	7.15000	0.74007	1.85000	2.76R
12	5.00000	6.85000	0.74007	-1.85000	-2.76R
23	3.00000	1.60000	0.74007	1.40000	2.09R
24	1.00000	2.40000	0.74007	-1.40000	-2.09R

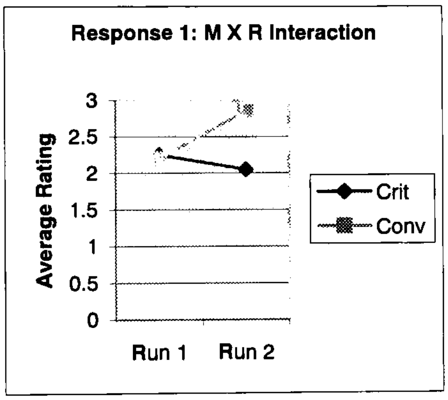
R denotes an observation with a large standardized residual.

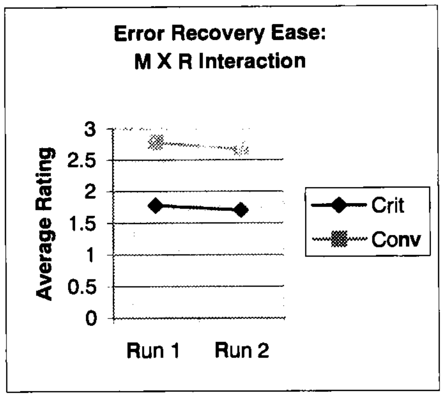
Summary of Significant Power Down ANOVA Results

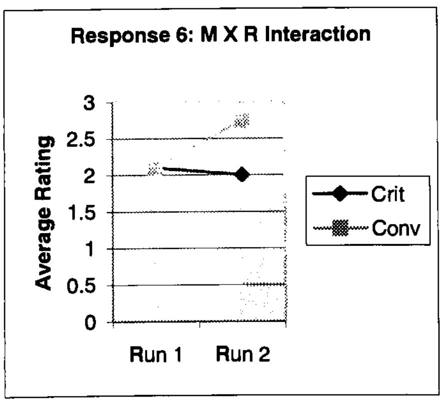
Significance Level: <= 0.01 | <= 0.05

Power Down	Method (M)		Delivery (D)		Run (R)		M X D		M X R		D X R		M X D X R	
Metric	F	p	F	p	F	p	F	p	F	p	F	p	F	p
Response 1: Ease of finding correct control & understanding labeling	1.820	0.211	0.010	0.933	1.260	0.268	0.060	0.800	4.510	0.041	1.890	0.178	1.890	0.178
Response 4: Ease of making corrections or error recovery	5.360	0.034	0.000	0.997	3.220	0.103	0.950	0.345	14.800	0.003	1.640	0.229	1.640	0.229
	Crit < Conv								<= 0.01					
Response 6: Overall ease of operation	1.800	0.188	0.200	0.657	4.590	0.039	0.390	0.535	8.540	0.006	0.040	0.847	0.950	0.336
									<= 0.01					

Crit < Conv Indicates Criterion subjects rated tasks as easier
Conv < Crit Indicates Conventional subjects rated tasks easier







Task 5. Power Down
Response variable: Response 1

Analysis of Variance for Response 1, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Method	1	2.8125	2.8125	2.8125	1.62	0.211
Delivery	1	0.0125	0.0125	0.0125	0.01	0.933
Run	1	1.0125	1.0125	1.0125	1.26	0.268
Method*Delivery	1	0.1125	0.1125	0.1125	0.06	0.800
Method*Run	1	3.6125	3.6125	3.6125	4.51	0.041
Delivery*Run	1	1.5125	1.5125	1.5125	1.89	0.178
Method*Delivery*Run	1	1.5125	1.5125	1.5125	1.89	0.178
Subject(Method Delivery)	36	62.4500	62.4500	1.7347	2.16	0.012
Error	36	28.8500	28.8500	0.8014		
Total	79	101.8875				

Unusual Observations for Response 1

Obs	Response	Fit	StDev Fit	Residual	St Resid
43	4.00000	2.60000	0.66390	1.40000	2.33R
44	1.00000	2.40000	0.66390	-1.40000	-2.33R

R denotes an observation with a large standardized residual.

Task 5. Power Down

Response variable: Response 4

Analysis of Variance for Response 4, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P	
Method	1	8.3236	9.9580	9.9580	5.36	0.034	x
Delivery	1	0.5083	0.0000	0.0000	0.00	0.997	x
Run	1	0.0828	0.5104	0.5104	3.22	0.103	
Method*Delivery	1	3.2860	1.7563	1.7563	0.95	0.345	x
Method*Run	1	0.0339	2.3437	2.3437	14.80	0.003	
Delivery*Run	1	0.2459	0.2604	0.2604	1.64	0.229	
Method*Delivery*Run	1	1.1869	0.2604	0.2604	1.64	0.229	
Subject(Method Delivery)	16	33.6905	33.6905	2.1057	13.30	0.000	
Error	10	1.5833	1.5833	0.1583			
Total	33	48.9412					

x Not an exact F-test.

Unusual Observations for Response 4

Obs	Response	Fit	StDev Fit	Residual	St Resid
5	3.00000	3.00000	0.39791	-0.00000	* X
15	5.00000	5.00000	0.39791	0.00000	* X
18	2.00000	2.00000	0.39791	-0.00000	* X
33	3.00000	3.00000	0.39791	0.00000	* X
39	5.00000	5.00000	0.39791	-0.00000	* X
72	4.00000	4.00000	0.39791	-0.00000	* X

X denotes an observation whose X value gives it large influence.

Task 5. Power Down

Response variable: Response 6

Analysis of Variance for Response 6, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Method	1	2.8125	2.8125	2.8125	1.80	0.188
Delivery	1	0.3125	0.3125	0.3125	0.20	0.657
Run	1	1.5125	1.5125	1.5125	4.59	0.039
Method*Delivery	1	0.6125	0.6125	0.6125	0.39	0.535
Method*Run	1	2.8125	2.8125	2.8125	8.54	0.006
Delivery*Run	1	0.0125	0.0125	0.0125	0.04	0.847
Method*Delivery*Run	1	0.3125	0.3125	0.3125	0.95	0.336
Subject(Method Delivery)	36	56.2500	56.2500	1.5625	4.75	0.000
Error	36	11.8500	11.8500	0.3292		
Total	79	76.4875				

Unusual Observations for Response 6

Obs	Response	Fit	StDev Fit	Residual	St Resid
21	4.00000	3.10000	0.42549	0.90000	2.34R
22	3.00000	3.90000	0.42549	-0.90000	-2.34R
29	1.00000	2.10000	0.42549	-1.10000	-2.86R
30	4.00000	2.90000	0.42549	1.10000	2.86R

R denotes an observation with a large standardized residual.

Summary of Significant Overall Impression ANOVA Results

Significance Level: <= 0.01 | <= 0.05

Overall Impression	Method (M)		Delivery (D)		Run (R)		M X D		M X R		D X R		M X D X R	
Metric	F	p	F	p	F	p	F	p	F	p	F	p	F	p
Response 1: Ease of finding correct control & understanding labeling	4.600	0.039	0.070	0.786	0.280	0.603	0.260	0.815	1.630	0.211	1.630	0.211	0.280	0.603
	Crit < Conv													
Response 4: Ease of making corrections or error recovery	11.860	0.001	0.630	0.433	0.010	0.944	0.060	0.813	0.180	0.676	1.510	0.236	0.010	0.944
	Crit < Conv													

Crit < Conv indicates Criterion subjects rated tasks as easier
Conv < Crit indicates Conventional subjects rated tasks easier

Task 6. Overall Impression of Interface

Response variable: Response 1

Analysis of Variance for Response 1, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P	
Method	1	16.2495	15.9211	15.9211	4.60	0.039	x
Delivery	1	0.3205	0.2579	0.2579	0.07	0.786	x
Run	1	0.3374	0.2579	0.2579	0.28	0.603	
Method*Delivery	1	1.1016	0.8895	0.8895	0.26	0.615	x
Method*Run	1	1.4128	1.5211	1.5211	1.63	0.211	
Delivery*Run	1	1.6900	1.5211	1.5211	1.63	0.211	
Method*Delivery*Run	1	0.2284	0.2579	0.2579	0.28	0.603	
Subject(Method Delivery)	36	127.0778	127.0778	3.5299	3.77	0.000	
Error	34	31.8000	31.8000	0.9353			
Total	77	180.2179					

x Not an exact F-test.

Unusual Observations for Response 1

Obs	Response	Fit	StDev Fit	Residual	St Resid
37	4.00000	5.60000	0.71723	-1.60000	-2.47R
38	8.00000	6.40000	0.71723	1.60000	2.47R
54	3.00000	3.00000	0.96711	0.00000	* X
71	3.00000	3.00000	0.96711	-0.00000	* X

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large influence.

Task 6. Overall Impression of Interface

Response variable: Response 4

Analysis of Variance for Response 4, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Method	1	33.1019	31.4620	31.4620	11.86	0.001 x
Delivery	1	0.3055	1.6663	1.6663	0.63	0.433 x
Run	1	1.5255	0.0048	0.0048	0.01	0.944
Method*Delivery	1	0.7635	0.1509	0.1509	0.06	0.813 x
Method*Run	1	0.0522	0.1741	0.1741	0.18	0.676
Delivery*Run	1	0.1012	1.4531	1.4531	1.51	0.236
Method*Delivery*Run	1	2.6792	0.0048	0.0048	0.01	0.944
Subject(Method Delivery)	33	96.3440	96.3440	2.9195	3.03	0.008
Error	18	17.3643	17.3643	0.9647		
Total	58	152.2373				

x Not an exact F-test.

Unusual Observations for Response 4

Obs	Response	Fit	StDev Fit	Residual	St Resid
3	7.00000	5.40000	0.76080	1.60000	2.58R
4	4.00000	5.60000	0.76080	-1.60000	-2.58R
7	3.00000	3.00000	0.98218	0.00000	* X
10	3.00000	3.00000	0.98218	0.00000	* X
14	3.00000	3.00000	0.98218	0.00000	* X
15	3.00000	4.40000	0.76080	-1.40000	-2.25R
16	6.00000	4.60000	0.76080	1.40000	2.25R
18	5.00000	5.00000	0.98218	0.00000	* X
20	3.00000	3.00000	0.98218	0.00000	* X
22	9.00000	9.00000	0.98218	-0.00000	* X
27	3.00000	3.00000	0.98218	0.00000	* X
35	3.00000	4.25000	0.77648	-1.25000	-2.08R
36	5.00000	3.75000	0.77648	1.25000	2.08R
38	6.00000	6.00000	0.98218	0.00000	* X
39	4.00000	4.00000	0.98218	0.00000	* X
48	3.00000	3.00000	0.98218	-0.00000	* X
54	3.00000	3.00000	0.98218	-0.00000	* X
60	3.00000	3.00000	0.98218	-0.00000	* X
71	3.00000	3.00000	0.98218	0.00000	* X
75	1.00000	1.00000	0.98218	0.00000	* X
80	3.00000	3.00000	0.98218	0.00000	* X

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large influence.

Appendix K: Subject Population Specifics and Comparisons by T-Test

Age: Two Sample T-Test and Confidence Interval

Method	N	Mean	StDev	SE Mean
Crit	20	20.90	1.17	0.26
Conv	20	22.20	5.45	1.2

95% CI for mu (Crit) - mu (Conv): (-3.90, 1.3)
T-Test mu (Crit) = mu (Conv)(vs not =): T = -1.04 P = 0.31 DF = 20

Age: Two Sample T-Test and Confidence Interval

Delivery	N	Mean	StDev	SE Mean
M	20	22.25	5.50	1.2
S	20	20.850	0.875	0.20

95% CI for mu (M) - mu (S): (-1.2, 4.00)
T-Test mu (M) = mu (S) (vs not =): T = 1.13 P = 0.27 DF = 19

Retention: Two Sample T-Test and Confidence Interval

Method	N	Mean	StDev	SE Mean
Crit	20	13.55	1.61	0.36
Conv	20	13.95	1.05	0.23

95% CI for mu (Crit) - mu (Conv): (-1.27, 0.47)
T-Test mu (Crit) = mu (Conv)(vs not =): T = -0.93 P = 0.36 DF = 32

Retention: Two Sample T-Test and Confidence Interval

Delivery	N	Mean	StDev	SE Mean
M	20	13.65	1.84	0.41
S	20	13.850	0.587	0.13

95% CI for mu (M) - mu (S): (-1.10, 0.70)
T-Test mu (M) = mu (S) (vs not =): T = -0.46 P = 0.65 DF = 22

Education: Two Sample T-Test and Confidence Interval

Method	N	Mean	StDev	SE Mean
Crit	20	12.200	0.894	0.20
Conv	20	12.30	1.34	0.30

95% CI for mu (Crit) - mu (Conv): (-0.83, 0.63)
T-Test mu (Crit) = mu (Conv)(vs not =): T = -0.28 P = 0.78 DF = 33

Education: Two Sample T-Test and Confidence Interval

Method	N	Mean	StDev	SE Mean
Crit	20	12.200	0.894	0.20
Conv	20	12.30	1.34	0.30

95% CI for mu (Crit) - mu (Conv): (-0.83, 0.63)
T-Test mu (Crit) = mu (Conv)(vs not =): T = -0.28 P = 0.78 DF = 33

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